PROJECT SPECIFICATIONS

Academic Classroom Build-Out
September 24, 2013
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**Academic Classroom Build-Out**

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

A. All drawings associated with the entire project, including general provisions of the Contract, including The General Conditions of the Contract for Construction, General and Supplementary Conditions and Division-1 Conditions specification sections shall apply to the Division 21 specifications and drawings. The Contractor shall be responsible for reviewing and becoming familiar with the aforementioned and all other Contract Documents associated with the project.

B. Related Sections: Refer to all sections in Division 21. Refer to Division 26 specification sections and Division 26 drawings.

C. Where contradictions occur between this section and Division 1, the more stringent requirement shall apply.

D. Contractor shall be defined as any and all entities involved with the construction of the project.

1.2 SUMMARY:

A. This Section specifies the basic requirements for mechanical installations and includes requirements common to more than one section of Division 21. It expands and supplements the requirements specified in Division 1.

1.3 MECHANICAL INSTALLATIONS:

A. The Contract Documents are diagrammatic, showing certain physical relationships which must be established within the mechanical work and its interface with all other work. Such establishment is the exclusive responsibility of the Contractor. Drawings shall not be scaled for the purpose of establishing material quantities.

B. Drawings and specifications are complementary. Whatever is called for in either is binding as though called for in both. Report any discrepancies to the Engineer and obtain written instructions before proceeding. Where any contradictions occur between the specifications and the drawings the more stringent requirement shall apply. The contractor shall include pricing for the more stringent and expensive requirements.

C. Drawings shall not be scaled for rough-in measurements or used as shop drawings. Where drawings are required for these purposes or have to be made from field measurement, Contractor shall take the necessary measurements and prepare the drawings.

D. The exact location for some items in this specification may not be shown on the drawings. The location of such items may be established by the Engineer during the progress of the work.

E. The contract documents indicate required size and points of terminations of pipes, and suggest proper routes to conform to structure, avoid obstructions and preserve clearances. It is not intended that drawings indicate necessary offsets. The contractor shall make the installation in such a manner as to conform to the structure, avoid obstructions, preserve headroom and keep openings and passageways clear, without further instructions or costs to the Owner. All equipment shall be installed so access is maintained for serviceability.
F. Before any work is installed, determine that equipment will properly fit the space; that required piping grades can be maintained and that ductwork can be run as intended without interferences between systems, structural elements or work of other trades.

G. Verify all dimensions by field measurements.

H. Coordinate installation in chases, slots and openings with all other building components to allow for proper mechanical installations.

I. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the work. Give particular attention to large equipment requiring positioning prior to closing-in the building.

J. Where mounting heights are not detailed or dimensioned, install mechanical services and overhead equipment to provide the maximum headroom possible.

K. Install mechanical equipment to facilitate maintenance and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.

L. Make allowance for expansion and contraction for all building components and piping systems that are subject to such.

M. The ceiling space shall not be “layered”. It is the contractor’s responsibility to offset and system as required to allow installation within the identified ceiling cavity. The contractor shall include labor and material in the base bid to accommodate such offsets.

N. In general, all “static” piping systems shall be routed as high as possible, i.e. fire protection systems. Keep all equipment in accessible areas such as corridors and coordinate with systems and equipment from other sections.

O. The Contractor shall provide all labor and material necessary but not limited to the starting/stopping of all mechanical equipment, opening/closing of all valves, draining/refilling all mechanical systems and operating/verifying the operation of all mechanical systems controls as required to accomplish all work necessary to meet construction document requirements. Contractor shall submit records of such activities to engineer and include in the O & M manuals.

P. All work shall operate in accordance with the Vibration, Siesmic and Sound Control specification under all conditions of load.

Q. Sound or vibration conditions not in accordance with the Vibration, Seismic and Sound Section and considered objectionable by the University shall be corrected in a manner approved by the project Architect under the work of Division 21/22/23.

1.4 COORDINATION:

A. Work out all installation conditions in advance of installation. The Contractor shall be responsible for preparing coordination drawings, showing all work, in all areas. The Contractor shall be responsible for providing all labor and material, including but not limited to all fittings, isolation valves, offsets, hangers, control devices, etc., necessary to overcome congested conditions at no increase in contract sum. The Contractors base bid shall include any and all time and manpower necessary to develop such coordination efforts and drawings. Increases to contract sum or schedule shall not be considered for such effort.
B. Provide proper documentation of equipment, product data and shop drawings to all entities involved in the project. Coordination shall include, but not be limited to the following:

1. Fire Protection and Fire Alarm Contractor shall provide shop drawings to all other Contractors.

2. Automatic Temperature Controls, Building Management and Testing, Adjusting and Balancing Contractors shall be provided with equipment product data and shop drawings from other Contractors and shall furnish the same information involving control devices to the appropriate Contractor.

C. Coordination Drawings (the following applies to all Division21/22/23 contractors):

1. Coordination drawings shall be prepared by the Contractor for his utilization and are his responsibility to assure systems will be installed in a manner to allow all systems to function properly.

2. Submit drawings for all areas, pay special attention to those places where clearances are limited, where space problems exist, for places where several elements of work (or combinations of mechanical and other work) must be located with precision in order to fit into available space, where sequencing is of importance to the efficient flow of work and as specified, and required.

3. Coordination drawings are informational submittals. Submit coordination drawings to Engineer for information only to document proper coordination of all portions of work and that coordination issues have been identified and resolved prior to submitting to the Engineer and prior to commencing construction in each affected area. The review of the coordination drawings by the Engineer does not constitute a relief of responsibility of the Contractor or a change to the contract documents. The Contractor shall have sole responsibility in developing a fully coordinated and integrated ceiling cavity.

4. The Contractor shall take the lead in coordinating and drawing Electrical and other Division 21, 22 & 23 components such as fire protection, plumbing, piping, sheet metal, etc. Where appropriate, the Contractor shall include medical gas, conduit, cable trays, pneumatic tube and any other system which may occupy the ceiling cavity.

5. Clearly indicate solutions to space problems. Identification of space problems without solutions is not acceptable. Only areas clearly identified will be reviewed.

6. All coordination drawings shall be 3D, with provision for collision check. The contractor is responsible for obtaining the architectural and structural files in 3D. All 3D drawing development, collision check, coordination, etc. shall be included as part of the Contractors base bid.

7. Prepare 3D Coordination Drawings (Shop Drawings) at a suitable scale, showing the required dimensions. In addition to the mentioned areas above, also submit the following:

   a. All mechanical equipment rooms such as fan rooms, boiler rooms, fire protection system rooms, etc. (1/4”=1'-0" scale).

   b. All building floor plans (1/8”=1 '-0” scale). Include all shafts with clearances.

   c. Air handling unit, etc. main duct connections and transitions in ceiling space and to shafts or horizontal ducts. (1/4”=1'-0”).

   d. Required access for all equipment requiring code or maintenance access.
e. All sections and elevations necessary for clarification.

f. Indicate all seismic restraint and support systems to be used for all mechanical equipment throughout the project.

g. Indicate locations of ceiling and wall access panels and other necessary access space.

h. Indicate duct and pipe elevations. Indicate clearances for installing and maintaining insulation.

i. Indicate access to isolation valves.

j. Indicate clearances for servicing and maintaining equipment, valve stem movement, and similar requirements.

k. Indicate movement and positioning of large equipment into the building during construction. Indicate pipe and duct size. Indicate equipment tags.

8. CADD Drawings: Electronic mechanical Revit drawings are available from the Engineer. Contact Engineer for further information in acquiring drawings. The Engineers Construction documents cannot be used directly for coordination drawings. They are for information and initial coordination only.

D. Utility Connections:

1. Coordinate connection of mechanical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies and controlling agencies. Provide required connection for each service.

2. The contract documents indicate the available information on existing utilities and services and on new services (if any) to be provided to the project by utility companies and agencies. Notify Engineer immediately if discrepancies are found.

3. Coordinate mechanical utility interruptions one week in advance with the Owner and the Utility Company. Plan work so that duration of the interruption is kept to a minimum.

1.5 COORDINATION WITH OTHER DIVISIONS:

A. General:

1. Coordinate all work to conform with the progress of the work of other trades.

2. Complete the entire installation as soon as the condition of the building will permit. No extras will be allowed for corrections of ill timed work, when such corrections are required for proper installation of other work.

B. Coordinate ceiling cavity space carefully with all trades. In the event of conflict, install mechanical and electrical systems within the cavity space allocation in the following order of priority:

1. Equipment and required clearances
2. Plumbing waste, cooling coil drain piping and roof drain mains and leaders.
3. Ductwork mains
4. Plumbing vent piping
5. Med gas/lab gas systems
6. Low pressure ductwork and air devices.
7. Electrical and communication conduits, raceways and cable tray.
8. Domestic hot and cold water
9. Hydronic piping
10. Fire sprinkler mains, branch piping and drops (locate as tight to structure as possible).
11. DDC control wiring and other low voltage systems.
12. Fire alarm systems.

C. Chases, Inserts and Openings:

1. Provide measurements, drawings and layouts so that openings, inserts and chases in new construction can be built in as construction progresses.
2. Check sizes and locations of openings provided. Including the access panels for equipment in hard lid ceilings and wall cavities.
3. Any cutting and patching made necessary by failure to provide measurements, drawings and layouts at the proper time shall be done at no additional cost in contract sum.

D. Support Dimensions: Provide dimensions and drawings so that concrete basis and other equipment supports to be provided under other sections of the specifications can be built at the proper time.

E. Coordinate the installation of required supporting devices and sleeves to be set in poured in place concrete and other structural components, as they are constructed.

F. Coordinate the cutting and patching of building components to accommodate the installation of mechanical equipment and materials. Refer to Division 1, 22 & 23.

G. Modifications required as result of failure to resolve interferences, provide correct coordination drawings or call attentions to changes required in other work as result of modifications shall be paid for by responsible Contractor/Subcontractor.

H. Coordination with Electrical Work: Refer to Divisions 1 and 26.

1.6 DESIGN WORK REQUIRED BY CONTRACTOR:

A. The construction of this project requires the Contractor to include the detailing and design of several systems and/or subsystems. All such design work associated with the development of the coordination drawings shall be the complete responsibility of the Contractor.

B. The Contractor shall take the full responsibility to develop and complete routing strategies which will allow fully coordinated system to be installed in a fully functional manner. The Engineers contract drawings shall be for system design intent and general configurations.

C. Systems or subsystems which require design responsibility by the contractor include but are not limited to:

1. Any system not fully detailed
2. Fire protection systems
3. Equipment supports, hangers, anchors and seismic systems not fully detailed nor specified in these documents, or catalogued by the manufacturer.
1.7 SAFETY:

A. Refer to Division 1.

1.8 EQUAL EMPLOYMENT OPPORTUNITY REQUIREMENTS:

A. Refer to Division 1 and conform with the Owners requirements.

1.9 REQUIREMENTS OF REGULATORY AGENCIES:

A. Refer to Division 1.

B. Execute and inspect all work in accordance with all Underwriters, local and state codes, 2009 UCB Standards, rules and regulations applicable to the trade affected as a minimum, but if the plans and/or specifications call for requirements that exceed these rules and regulations, the greater requirement shall be followed. Follow recommendations of NFPA, SMACNA, EPA, OSHA and ASHRAE.

C. Comply with standards in effect at the date of these Contract Documents, except where a standard or specific date or edition is indicated.

D. The handling, removal and disposal of regulated refrigerants shall be in accordance with U.S. EPA, state and local regulations.

E. The handling, removal and disposal of lead based paint and other lead containing materials shall comply with EPA, OSHA, and any other Federal, State, or local regulations.

F. After entering into contract, Contractor will be held to complete all work necessary to meet these requirements without additional expense to the Owner.

1.10 REQUIREMENTS OF LOCAL UTILITY COMPANIES:

A. Comply with rules and regulations of local utility companies. Include in bid the cost of all valves, valve boxes, meter boxes, meters and such accessory equipment which will be required but not provided by Local Utility Company for the project.

1.11 PERMITS AND FEES:

A. Refer to Division 1.

B. The Contractor shall pay all tap, development, meter, etc., fees required for connection to municipal and public utility facilities, unless directed otherwise by the General Contractor/Owner – IN WRITING.

C. Contractor shall arrange for and pay for all inspections, licenses and certificates required in connection with the work.

1.12 TEMPORARY FACILITIES:

A. Light, Heat, Power, Etc.: Responsibility for providing temporary electricity, heat and other facilities shall be as specified in Division 1.

B. Construction Fire Protection stand pipe: Refer to 21 10 00
1.13 PRODUCT OPTIONS AND SUBSTITUTIONS:

A. Refer to the Instructions to Bidders and Division 1.

1.14 MECHANICAL SUBMITTALS:

A. General

1. Refer to the Conditions of the Contract (General and Supplementary), Division 1.

2. The submittals shall be submitted as one package identified by the specification section. Submittals that are not complete with the required information will be sent back to be corrected.

3. The Contractor shall identify any "long lead time" items which may impact the overall project schedule. If these submittal requirements affect the schedule, the Contractor shall identify the impacts and confer with the Engineer within two weeks of entering into the contract.

4. The submittal package shall be provided in electronic format. The cover shall be identified with the job name, Owner's project number, date, Prime Contractor's name, etc.

5. An index shall be provided which includes:
   a. Product
   b. Plan Code (if applicable)
   c. Specification Section
   d. Manufacturer and Model Number

6. All mechanical divisions shall be submitted at one time. Long lead items may be submitted prior to full submittal if necessary.

7. Fire protection and coordination drawings do not apply to the above. These drawings may be submitted in a separate submittal.

B. The manufacturer's material or equipment listed in the schedule or identified by name on the drawings are the types to be provided for the establishment of size, capacity, grade and quality. If alternates are used in lieu of the scheduled names, the cost of any changes in construction required by their use shall be borne by Contractor.

C. All equipment shall conform to the State and/or local Energy Conservation Standards and UCB requirements.

D. Submittal of shop drawings, product data and samples will be accepted only when submitted by and stamped by the General Contractor. Data submitted from Subcontractors and material suppliers directly to the Engineer will not be processed unless prior written approval is obtained by the General Contractor.

E. Before starting work, prepare and submit to the Architect/Engineer all shop drawings and descriptive equipment data required for the project. Unless each item is identified with specification section and sufficient data to identify its compliance with the specifications and drawings, the item will be returned "Revise and Resubmit". Where an entire submittal package is returned for action by the Contractor, the Engineer will summarize comments in letter format and return the entire set. Continue to submit any individual shop drawings, product data or samples which were returned without a "make corrections noted" or "no exceptions taken" action, until they are so marked. When a "Make Corrections Noted" is
received, make the required corrections for inclusion in the operation and maintenance manual. Submittals marked "Make Corrections Noted" shall not be resubmitted during the submittal process.

F. The Design Professional’s review and appropriate action on all submittals and shop drawings is only for the limited purpose of checking for conformance with the design concept and the information expressed in the contract documents. This review shall not include:

1. Accuracy or completeness of details, such as quantities, dimensions, weights or gauges, fabrication processes
2. Construction means or methods
3. Coordination of the work with other trades
4. Construction safety precautions

G. The Design Professional’s review shall be conducted with reasonable promptness while allowing sufficient time in the Design Professional’s judgment to permit adequate review. Review of a specific item shall not indicate that the Design Professional has reviewed the entire assembly of which the item is a component.

H. **The Design Professional shall not be responsible for any deviations from the contract documents not brought specifically to the attention of the Design Professional in writing by the Contractor.** This shall clearly identify the design and the specific element which vary from the Design. The Contractor shall be responsible for all remedy for lack of strict conformance associated with this criteria.

I. The Design Professional shall not be required to review partial submissions or those for which submissions of correlated items have not been received.

1.15 **SPECIFIC CATEGORY SUBMITTAL REQUIREMENTS:**

A. Product Data:

1. Where pre-printed data covers more than one distinct product, size, type, material, trim, accessory group or other variation, mark submitted copy with black pen to indicate which of the variations is to be provided.

2. Delete or mark-out portions of pre-printed data which are not applicable.

3. Where operating ranges are shown, mark data to show portion of range required for project application.

4. For each product, include the following:
   a. Sizes.
   b. Weights.
   c. Speeds.
   d. Capacities.
   e. Piping and electrical connection sizes and locations.
   f. Statements of compliance with the required standards and regulations.
   g. Performance data.
   h. Manufacturer's specifications.

B. Shop Drawings:

1. Shop Drawings are defined as mechanical system layout drawings prepared specifically for this project, or fabrication and assembly type drawings of system components to show more detail than typical pre-printed materials.
2. Prepare Mechanical Shop Drawings, except diagrams, to accurate scale, min 1/8"-1'-0", unless otherwise noted.
   a. Show clearance dimensions at critical locations.
   b. Show dimensions of spaces required for operation and maintenance.
   c. Show interfaces with other work, including structural support.

3. Provide plumbing isometrics, with locations of isolation valves shown.

C. Test Reports:
   1. Submit test reports which have been signed and dated by the accredited firm or testing agency performing the test.
   2. Prepare test reports in the manner specified in the standard or regulation governing the test procedure (if any) as indicated.
   3. Submit test reports as required for O & M manuals.

D. Product Listing:
   1. Prepare listing of major mechanical equipment and materials for the project, within (2) two weeks of signing the Contract Documents and transmit to the Architect. A sample schedule is included at the end of this section to complete this requirement.
      a. Provide all information requested.
      b. Submit this listing as a part of the submittal requirement specified in Division 1, "PRODUCTS AND SUBSTITUTION."
   2. Unless otherwise specified, all materials and equipment shall be of domestic (USA) manufacture and shall be of the best quality used for the purpose in commercial practice.
   3. When two or more items of same material or equipment are required (plumbing fixtures, pumps, valves, air conditioning units, etc.) they shall be of the same manufacturer. Product manufacturer uniformity does not apply to raw materials, bulk materials, pipe, tube, fittings (except flanged and grooved types), sheet metal, wire, steel bar stock, welding rods, solder, fasteners, motors for dissimilar equipment units and similar items used in work, except as otherwise indicated.
      a. Provide products which are compatible within systems and other connected items.

E. Schedule of Values
   1. Provide preliminary schedule of values with product data submittal, within three (3) weeks from award of contract to successful bidder. Provide according to the following descriptions:
      a. Fire Protection
   2. Provide a final Schedule of Values at close-out of project including updated values based on actual installation.

F. Coordination Drawings: See section 1.4 of this specification section.

G. Required Submittals: Provide submittals for each item of equipment specified or scheduled in the contract documents. See table at the end of this section.
H. If more than two submittals (either for product data, shop drawings, record drawings, or test and balance reports) are made by the Contractor, the Owner reserves the right to charge the Contractor for subsequent reviews by their consultants. Such extra fees shall be deducted from payments by the Owner to the Contractor.

1.16 DELIVERY, STORAGE, AND HANDLING:

A. Refer to Division 1.

B. Deliver products to project properly identified with names, model numbers, types, grades, compliance labels and similar information needed for distinct identifications; adequately packaged and protected to prevent damage or contamination during shipment, storage, and handling.

C. Check delivered equipment against contract documents and submittals.

D. Store equipment and materials at the site, unless off-site storage is authorized in writing. Protect stored equipment and materials from damage, dirt, dust, freezing, heat and moisture.

E. Coordinate deliveries of mechanical materials and equipment to minimize construction site congestion. Limit each shipment of materials and equipment to the items and quantities needed for the smooth and efficient flow of installations.

F. Provide factory-applied plastic end-caps on each length of pipe and tube, except for concrete, corrugated metal, hub-and-spigot, clay pipe. Maintain end-caps through shipping, storage and handling to prevent pipe-end damage and prevent entrance of dirt, debris and moisture.

G. Protect stored ductwork, pipes and tubes. Elevate above grade and enclose with durable, waterproof wrapping. When stored inside, do not exceed structural capacity of the floor.

H. Protect flanges, fittings and specialties from moisture and dirt by inside storage and enclosure, or be packaging with durable, waterproof wrapping.

I. Protect sheet metal ductwork and fittings. Elevate and store above grade and cover ends with waterproof wrapping.

1.17 CUTTING AND PATCHING:

A. This Article specifies the cutting and patching of mechanical equipment, components and materials to include removal and legal disposal of selected materials, components and equipment.

B. Refer to Division 1.

C. Do not endanger or damage installed work through procedures and processes of cutting and patching.

D. Arrange for repairs required to restore other work, because of damage caused as a result of mechanical installations.

E. No additional compensation will be authorized for cutting and patching work that is necessitated by ill-timed, defective or non-conforming installations.

F. Perform cutting, fitting and patching of mechanical equipment and materials required to:

1. Uncover work to provide for installation of ill-timed work;
2. Remove and replace defective work;
3. Remove and replace work not conforming to requirements of the Contract Documents;
4. Remove samples of installed work as specified for testing;
5. Install equipment and materials in existing structures;
6. Upon written instructions from the Architect/Engineer, uncover and restore work to provide for Architect/Engineer observation of concealed work.

G. Construction and pre-occupancy indoor air quality (AQ) management:

1. During construction, meet or exceed the recommended design approaches of the SMACNA 1 AQ guideline for occupied buildings under construction, 1995, Chapter 3.

1.18 ROUGH-IN:

A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

B. Refer to equipment shop drawings and manufacturer's requirements for actual provided equipment for rough-in requirements.

C. Work through all coordination before rough-in begins.

1.19 ACCESSIBILITY:

A. Install equipment and materials to provide required access for servicing and maintenance. Coordinate the final location of concealed equipment and devices requiring access with final location of required access panels and doors. Allow 36” clearance for removal of all parts that require replacement or servicing.

B. Extend all grease fittings to an accessible location.

C. Furnish hinged steel access doors with concealed latch, whether shown on drawings or not, in all walls and ceilings for access to all concealed valves, shock absorbers, air vents, motors, dampers, equipment controls, fans, balancing cocks, and other operating devices requiring adjustment or servicing. Refer to Division 1 for access door specification and Division 21 for duct access door requirements.

D. The minimum size of any access door shall not be less than the size of the equipment to be removed or 24 inches x 24 inches if used for service only.

E. Furnish doors to trades performing work in which they are to be built, in ample time for building-in as the work progresses. Whenever possible, group valves, cocks, etc., to permit use of minimum number of access doors within a given room or space.

F. Factory manufactured doors shall be of a type compatible with the finish in which they are to be installed. In lieu of these doors, approved shop fabricated access doors with DuroDyne hinges may be used.

G. Access doors in fire-rated walls and ceilings shall have equivalent U.L. label and fire rating.

1.20 EXCAVATING AND BACKFILLING:

A. General:
1. Provide all necessary excavation and backfill for installation of mechanical work in accordance with Division 2.

B. Contact Owners of all underground utilities to have them located and marked, at least 2 business days before excavation is to begin. Also, prior to starting excavation brief employees on marking and color codes and train employees on excavation and safety procedures for natural gas lines. When excavation approaches gas lines, expose lines by carefully probing and hand digging.

C. Provide all necessary pumping, cribbing and shoring.

D. Walls of all trenches shall be a minimum of 6 inches clearance from the side of the nearest mechanical work. Install pipes with a minimum of 6 inches clearance between them when located in same trench.

E. Pipe Trenching:

1. Dig trenches to depth, width, configuration, and grade appropriate to the piping being installed. Dig trenches to 6 inches below the level of the bottom of the pipe to be installed. Install 6 inches bed of pea gravel or squeegee, mechanically tamp to provide a firm bed for piping, true to line and grade without irregularity. Provide depressions only at hubs, couplings, flanges, or other normal pipe protrusions.

F. Backfilling shall not be started until all work has been inspected, tested and accepted. All backfill material shall be reviewed by the soils engineer. In no case shall lumber, metal or other debris be buried in with backfill.

1. Provide warning tape for marking and locating underground utilities. Tape shall be specifically manufactured for this purpose and shall be polyethylene film, 6 inches wide, 0.004 inches thick and have a minimum strength of 1750 psi. Tape shall carry continuous inscription naming the specific utility.

a. Tape shall have magnetic strip and be used for exterior underground system only.

G. Trench Backfill:

1. Backfill to 12 inches above top of piping with pea gravel or squeegee, the same as used for piping bed, compact properly.

2. Continue backfill to finish grade, using friable material free of rock and other debris. Install in 6 inch layers, each properly moistened and mechanically compacted prior to installation of ensuing layer. Compaction by hydraulic jetting is not permissible.

H. After backfilling and compacting, any settling shall be refilled, tamped, and refinished at this contractor's expense.

I. This contractor shall repair and pay for any damage to finished surfaces.

J. Complete the backfilling near manholes using pea gravel or squeegee, installing it in 6 inch lifts and mechanically tamping to achieve 95 percent compaction.

K. Use suitable excavated material to complete the backfill, installed in 6 inch lifts and mechanically compacted to seal against water infiltration. Compact to 95 percent for the upper 30 inches below paving and slabs and 90 percent elsewhere.
1.21 NAMEPLATE DATA:

A. Provide permanent operational data nameplate, on each item of mechanical equipment, indicating manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliances, and similar essential data. Locate nameplates in an accessible location. Coordinate with Owner for specific requirements.

B. Campus Famis labels will be provided by UCB for contractor to install.

1.22 LUBRICATION OF EQUIPMENT:

A. Refer to Division 1. The following paragraphs supplement the requirements of Division 1.

B. Contractor shall properly lubricate all mechanical pieces of equipment which he provided before turning the building over to the Owner. He shall attach a linen tag or heavy duty shipping tag on the piece of equipment showing the date of lubrication and the type and brand of lubricant used.

C. Furnish the Engineer with a typewritten list included in the O and M manuals of each item lubricated and type of lubricant used, no later than two (2) weeks before completion of the project, or at time of acceptance by the Owner of a portion of the building and the mechanical systems involved.

1.23 CLEANING:

A. Refer to Division 1.

1.24 RECORD DOCUMENTS:

A. Refer to Division 1. The following paragraphs supplement the requirements of Division 1.

B. Keep a complete set of record document prints in custody during entire period of construction at the construction site. Documents shall be updated on a weekly basis.

C. Mark Drawing Prints to indicate revisions to piping and ductwork, size and location both exterior and interior; including locations of coils, dampers and other control devices, filters, boxes, and similar units requiring periodic maintenance or repair; actual equipment locations, dimensioned from column lines; actual inverts and locations of underground piping; concealed equipment, dimensioned to column lines; mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located (i.e., traps, strainers, expansion compensators, tanks, etc.); Change Orders; concealed control system devices. Changes to be noted on the drawings shall include final location of any piping or ductwork relocated more than 1 foot-0 inches from where shown on the drawings.

D. At the completion of the project, obtain from the Architect a complete set of the Construction Documents in the electronic format used by the design team. This set will include all revisions officially issued through the Architect. The Contractor shall transfer all revisions noted on the record document prints to the electronic drawings. The Contractor shall transmit the final record documents in the electronic format used on the project to the Architect. This contract will not be considered completed until these record drawings have been received and reviewed by the Architect/Engineer.

1.25 OPERATION AND MAINTENANCE DATA:

A. Refer to Division 1.
B. In addition to the information required by Division 1 for Maintenance Data, include the following information:

1. Description of mechanical equipment, function, installation instructions, drawing specification, complete wiring and temperature controls diagrams, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of all replaceable parts.

2. Manufacturer's printed operating procedures to include start-up, break-in, routine and normal operating instructions; regulation, control, stopping, shut-down, and emergency instructions; and summer and winter operating instructions. Provide any test reports and start-up documents.

3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.

4. Servicing instructions, lubrication charts and schedules, including Contractor lubrication reports.

5. Manufacturer's service manuals for all mechanical equipment provide under this contract.

6. Include the valve tag list.

7. Alphabetical list of all system components including the name, address and 24 hour phone number of the company responsible for servicing each item during the 1st year’s operation.

8. Starting, stopping, lubrication, equipment identification numbers and adjustment clearly indicated for each piece of equipment.

9. Complete parts list. Provide to Owner, recommended spare parts list.

10. Mechanical warranties.

11. Final schedule of values with all mechanical change order costs included and identified.


13. Appropriate start-up information by factory representative.

14. On-site dynamic balancing report by independent balancing firms of all Labs.

C. This contract will not be considered completed nor will final payment be made until all specified material, including testing and balancing report and final schedule of values with all mechanical change order costs included and identified, is received in this operating and maintenance report and the manual is reviewed by the Architect.

1.26 PROJECT CLOSEOUT:

A. In addition to the requirements specified in Division 1, complete the requirements listed below.

B. The Contractor shall be responsible for the following Mechanical Checklist either by performing and/or coordinating such items prior to applying for certification of substantial completion. Refer to individual specification sections for additional requirements.
C. Contractor shall be responsible for scheduling instructional meetings for maintenance personnel on the proper operation and maintenance of all mechanical systems, using the “Operation and Maintenance Manual” as a guide.

1.27 WARRANTIES:

A. Refer to the Division 1 for procedures and submittal requirements for warranties. Refer to individual equipment specifications for warranty requirements. In any case the entire mechanical system shall be warranted no less than one year from the time of acceptance by the Owner.

B. Compile and assemble the warranties specified in Division 21, 22 & 23, into the operating and maintenance manuals.

C. Provide complete warranty information for each item to include product or equipment to include date or beginning of warranty or bond; duration of warranty or bond; and names, addresses, and telephone numbers and procedures for filing a claim and obtaining warranty services.

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1 For Soft Starters and Variable Frequency Drives
2 Requires Review & Approval from T & B Contractor
3 Warranty Report/Warranty
4 Kitchen Exhaust Hood
5 See Specific Specification Section for Test & Certification Requirements

END OF SECTION 21 05 00
SECTION 21 10 00
FIRE PROTECTION

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:
A. This Section specifies automatic sprinkler systems for buildings and structures. Materials and equipment specified in this Section include:
   - Pipe, fittings, valves and specialties.
   - Sprinklers and accessories.
B. Products furnished but not installed include sprinkler head cabinet with spare sprinkler heads. Furnish to the Owner's maintenance personnel.
C. The work of this section includes engineering by the Contractor. The Contractor shall act as Engineer of record for all fire protection work.

1.2 DEFINITIONS:
A. Pipe sizes used in this Specification are Nominal Pipe Size (NPS).
B. Other definitions for fire protection systems are listed in NFPA Standards 13, 13R, 14, 20 and 24.
C. Working plans as used in this Section means those documents (including drawings and calculations) prepared pursuant to the requirements contained in NFPA 13 and 14 for obtaining approval of the authority having jurisdiction.

1.3 SYSTEM DESCRIPTION:
A. Provide a complete fire sprinkler system for the entire building (including, but not limited to, electrical rooms, mechanical penthouses and accessible sections of air handling units,) except designated areas as shown on the drawings which will not require fire sprinkler coverage will be specifically noted with "No A/S".
B. Fire protection system is a "wet-pipe" system employing automatic sprinklers attached to a piping system containing water and connected to a water supply so that water discharges immediately from sprinklers opened by fire.
C. Double Interlocked Preaction System: The double interlocked preaction system utilizes a detector system and pressurized air in the sprinkler piping. This system utilizes the deluge valve and is so arranged that the valve will open only when both pressure reduced in the sprinkler piping and the detection system operates. If the detection system operates due to fire, damage, or malfunction, the valve will not open. If the sprinkler piping is damaged or sprinkler is broken or fused, the valve will not open. The operation of both a sprinkler and a detector (or release) is required before the valve will open allowing water to enter the system piping. The system shall be supervised. Provide manual release as required by NFPA-13. Detection system and wiring to preaction panel or fire alarm panel by Division 26.
D. Fire protection system is a "Class I, Standpipe and Hose" system which is an arrangement of piping, valves, hose connections and allied equipment.
1.4 SUBMITTALS:

A. Product data for each type sprinkler head, valve, piping and piping specialty, fire protection specialty, fire department connection and any equipment installed in accordance with the Contract Documents. Index per specification chapter and item number. Partial submittals shall not be acceptable.

B. Shop drawings prepared in accordance with NFPA 13 identified as "working plans," including detailed riser schematics indicating pipe sizes and lengths; and hydraulic calculations where applicable, which have been approved by the authority having jurisdiction. The plans shall be created in CAD format consistent with UCB CAD standards. Do not proceed with the installation of the work until the Architect/Engineer and AHJ review of shop drawings is received.

C. Contractor shall stamp shop drawings indicating compliance with applicable codes and contract drawings. Contractor shall stamp drawing "Approved for Construction."

D. When a fire protection system employs electronic file detection devices to activate a system, e.g., in preaction and deluge systems, detailed fire detection and alarm shop drawings, shall accompany the fire protection shop drawing submittal under appropriate division, Division-21 or 26, as determined by the Engineer.

E. The drawings shall show the location and ratings of all fire rated floors and walls. Each pipe penetration of these rated assemblies shall be detailed on the drawings showing pipe sleeve and a fire rated penetration seal.

F. Completed State of Colorado Plan Registration Form shall accompany the shop drawing submittal.

G. If more than two submittals (either for shop drawings or for record drawings) are made by the contractor, the Owner reserves the right to charge the contractor for subsequent reviews by their consultants. Such extra fees shall be deducted from payments by the Owner to the contractor.

H. Maintenance data for each type sprinkler head, valve, piping specialty, fire protection specialty, fire department connection and hose valve specified, for inclusion in operating and maintenance manual specified in Division 1 and Division-21 Section "Common Work Results for Fire Suppression."

I. Welder's qualification certificate.


K. Hydraulic calculations and drawings submitted to the Engineer shall be prepared under the direct supervision of and bear the signed stamp of a professional engineer registered in the State of Colorado and familiar with this type of installation and with previous similar experience (practicing in the Fire Protection field) certifying that the fire sprinkler system has been designed and hydraulically calculated in compliance with NFPA and governing codes. No design related work shall be subcontracted or performed by persons other than bona fide employees working solely for the contractor.

L. Fire sprinkler piping design drawings shall show all ductwork, air devices, lighting and electrical panels.

M. Shop drawings and hydraulic calculations shall be stamped and signed by the local fire prevention authority prior to submitting shop drawings to the Architect/Engineer.

N. Submit anchoring details and calculations.
O. Final as-built drawings shall be provided and created in a CAD format consistent with UCB CAD standards.

1.5 HYDRAULIC DESIGN:

A. The Fire Sprinkler System shall be hydraulically calculated by the Contractor. Pipe schedule method is acceptable only as allowed in NFPA 13 5-2.2.

B. The wet pipe fire sprinkler system for the building shall be hydraulically calculated to comply with NFPA-13 and the following criteria:

1. Light hazard occupancy for areas unless noted otherwise.

2. Ordinary hazard occupancy for the following:
   a. Where noted or shown on drawings.
   b. Commercial Kitchens
   c. Laundries
   d. Parking Garages
   e. Library Stack Areas
   f. Laboratories


C. The final fire protection system demand shall be a minimum of 10 PSI below the water supply curve.

D. Velocities in pipes shall be shown on hydraulic calculations. Velocities in overhead piping shall not exceed 20 feet per second. Velocities in underground piping shall not exceed 16 feet per second.

E. Allow 10 feet of loss for electric water flow switches and note on hydraulic calculations.

F. The Fire Protection Contractor shall provide as many sets of hydraulic calculations as necessary, performed and submitted to prove that the most remote and demanding areas are calculated.

G. Design information shall be permanently affixed to the main riser as described in NFPA Pamphlet 13.

H. Water flow data for bidding purposes only is:

   135 psi static
   130 psi residual with 1600 gpm flowing

I. The Fire Protection Contractor shall perform a water flow test as described in part 3.1-A.3.

J. The pipe and valve sizes indicated on the drawings and details are minimum sizes to be used regardless of sizes allowed by hydraulic calculations.

   1. If a condition arises that is not clearly identified in the Contract Documents, design direction shall be provided in writing by the Engineer. This includes, but is not limited to, walls relocated or not shown on the plans, potential freezing points, ducts and other obstructions, or interferences as they relate to system coverage or hydraulic performance parameters.

   2. The Contractor shall be ultimately responsible to guarantee the system against freezing for reasons other than that of the building Owner’s negligence.
1.6 SYSTEM DESCRIPTION:

A. General Design Requirements:

1. The fire sprinkler system shall be equipped with an exterior local alarm (bell and strobe) initiated by the flow detection device. Coordinate with Division 26.

2. The 100% design drawings prepared by the Engineer indicate principal pipe layouts, including risers and cross-mains. They do not show every required offset, dimension, fitting, or similar details. Contract Document drawings shall not be used as shop drawings.

B. Miscellaneous Requirements:

1. System Sub-Section Zoning:

   a. Sub-section zoning shall be accomplished by providing individual zone water flow detection, zone control valve, zone drain, gauge and inspectors test connection.

   b. Sub-section zoning shall be provided for the following areas:

      1) Elevator Machine Rooms and Shafts.
      2) Transformer rooms (double interlock preaction system).

   c. When a building exceeds three (3) floor levels (including basement) the sprinkler system on each floor shall be a separate zone.

   d. When a floor area exceeds 10,000 square feet, it shall be on a separate zone.

   e. As required by NFPA-13 under protection area limitations.

2. Preaction System:

   a. Coordinate work with Electrical.

   b. All preaction system piping shall be supervised by an approved method.

   c. For combined dry and preaction systems, the nitrogen supply shall meet the requirements for dry pipe systems.

   d. Preaction valve assemblies shall be electronically released through an approved releasing panel. This shall be coordinated with Division 26 work.

   e. Activation shall be by means of automatic fire detection with manual release capability. These devices shall be coordinated with Division 26 work.

   f. Automatic fire detection devices shall be spaced according to NFPA 72.

   g. System activation method/sequencing, coordinate with Division 26.

      1) Detection method shall be by one or more of the following:

         a) Smoke detectors
         b) Loss of nitrogen pressure

      2) Sequence of operation for valve actuation shall follow:
a) Automatic Detector Signal(s) and Loss of Air

h. Type

1) Double interlocked preaction systems that admit water to sprinkler piping upon operation of both detection devices and automatic sprinklers.

3. Requirements for Mitigation of Microbiologically Induced Corrosion (MIC)

a. Pipes and Tubes:

1) All piping shall be USA manufactured steel Schedule 10 or 40 and shall have an Antibacterial Formula™ (ABF) coating or approved equal.

2) For wet pipe systems, all piping shall be steel Schedule 10 or 40 for 2-1/2” and larger, and schedule 40 for all pipe 2” and smaller. For 2” and smaller pipe, threadable thin wall pipe may be used only if the threaded Corrosion Resistance Ratio is greater than or equal to 1.0.

3) For preaction systems, all piping shall be steel Schedule 40. For 2-1/2” and larger, cut-groove the pipe for grooved fittings. Roll grooved pipe shall not be accepted. For all pipe sizes, threadable thinwall pipe may be used only if the Corrosion Resistance Ratio is greater than or equal to 1.0 as installed within the system, i.e., threaded or cut-grooved as applicable.

4) For drain pipes, all piping shall be galvanized steel Schedule 10 or 40 for 2-1/2” and larger and schedule 40 for all pipe 2” and smaller. For 2” and smaller pipe, threadable thinwall pipe may be used only if the threaded Corrosion Resistance Ratio is greater than or equal to 1.0.

b. Pipe and Tube Fittings:

1) All pipe 2” and smaller shall have threaded fittings. The only exception to this requirement is at locations where unions would be required, grooved fittings may be used in place of unions. The number of grooved fittings for 2” and smaller pipe shall not exceed 1% of the total number of fittings installed on the system. Threaded fitting shall be either malleable or cast iron.

2) For 2-1/2” and larger pipe, all fittings shall be ductile iron grooved fittings. For the preaction systems, provide grooved fittings and gaskets that are listed for dry-pipe systems. Grooved fittings shall be of a type that does not require field lubrication; Victaulic Vic-Plus or approved equal.

c. Nitrogen Pressure System:

1) In order to reduce the likelihood of microbiologically induced corrosion (MIC), nitrogen is to be used in place of air for all preaction and dry systems.

2) Provide two nitrogen tanks of adequate size, e.g., size “Q” or larger, to supply supervisory pressure to preaction systems.

3) Nitrogen tanks shall be positioned to discourage accidental damage to the tanks, valves and regulators. Secure tanks to walls or provide freestanding rakes to securely restrain tanks. Show location on shop drawings.
4) Provide Nitrogen Regulating Device (Reliable or approved equal) to reduce the pressure from 2200 psi to approximately 50 psi. Nitrogen Regulating Device shall be located as close to tanks as possible to minimize high-pressure piping. Provide rigid pipe from the Nitrogen Regulating Device to each preaction system.

5) Provide a low pressure supervisory switch to monitor the pressure within the pipe between the Nitrogen Regulating Device and each Pressure Maintenance Device for each preaction system. This low pressure supervisory switch shall be set to provide a supervisory signal if the pipe pressure is less than 20 psi below the normal operating pressure.

6) For each preaction system, provide an approved pressure maintenance device, e.g., Reliable Model C Pressure Maintenance Device, or approved equal, to reduce the pressure form 50 psi to approximately 30 oz/in². Pressure Maintenance Devices shall be adequately supported. Contractor is to construct rack or similar system to support these and other devices as necessary. Configure Pressure Maintenance Device as required by manufacture’s data sheets.

7) Provide a low-pressure switch, Reliable or approved equal, which is factory set to 11 oz/in² to supervise pressure within the preaction system.

8) Provide gauge on each preaction system that is listed to monitor oz/in². Provide second gauge on each preaction system for water pressure.

d. Installation:

1) In the preaction systems, all piping shall be sloped to facilitate drainage toward the point of the supply. Slope shall be provided as required for dry systems per NFPA 13. All trapped sections of piping shall be provided with auxiliary drains as required by NFPA 13. Drum drips shall not be required. However, all drains shall be a minimum of 1” valves with plug at all low points. This requirement exceeds the provisions of NFPA 13.

e. Sprinklers:

1) For the preaction system, use upright sprinklers. Pendent sprinklers shall not be used with the preaction system. Where pendent sprinklers are required due to suspended ceilings, Contractor shall provide dry pendent sprinklers installed in manner that no trapped water will result. Sidewall sprinklers may be used on the preaction system as long as they are installed so that no trapped water will occur.

4. Standpipe Systems:

a. The system shall be designed as required by NFPA #14 and IBC/IFC.

b. Hose valves shall be located within the building stairway enclosures, with additional corridor locations as required, unless alternative locations are approved by the AHJ in writing.

c. Approved roof manifolds shall be provided where required by the UBC or by the AHJ. Roof manifolds shall be minimum 4” with two (2) 2-1/2” gated outlets with the interior control valve operable from the roof location. Suitable and accessible manual drains and automatic drip drains shall be provided per NFPA 14.

d. Standpipe systems shall b hydraulically calculated for the project specific requirements.
5. Elevator and Electrical Equipment:
   a. The installation of sprinkler systems in elevator machine rooms and shafts shall be in compliance with the requirements of ANSI A-17.1. Coverage shall be designed for Ordinary Hazard, Group One.
   b. Each bank of elevators and associated equipment rooms shall be protected by an independent system unless determined otherwise by the Engineer and approved by AHJ.

6. Protection for Mechanical Shafts:
   a. Sprinklers shall be required in all shafts where the shaft construction or contents are combustible or where the shaft is accessible by personnel.
      
      EXCEPTION: For shafts housing a single duct which occupies the entire area of the shaft, sprinklers are not required.
   b. Where sprinklers are provided in shafts, they shall be accessible for inspection, maintenance or repair and replacement.
   c. Sprinkler heads shall be placed at the top of all shafts requiring protection.
   d. The coverage and spacing limitations from NFPA #13 shall be complied with.

1.7 QUALITY ASSURANCE:

A. Contractor shall be pre-qualified by the University to work on any major projects.

B. The entire fire protection system project including design, calculations, installation and testing, excluding prefabrication, shall be bid by a single firm which has the capabilities to perform all of the work required under this contract. No installation work shall be sub-contracted without prior permission in writing from the AHJ.

C. Fire Protection Contractor, individually shall be able to provide bonding capacity equal to the total amount of the fire protection portion of the contract, for the specific project. Refer to Section 1 – Bonding Requirements.

D. Installer Qualifications: Installation and alterations of fire protection piping, equipment, specialties, and accessories, and repair and servicing of equipment shall be performed only by qualified installer. The term qualified means experienced in such work (experienced shall mean having a minimum of 5 years, experience in the design and installation of similar products of comparable size and value, familiar with all precautions required, and has complied with all the requirements of the authority having jurisdiction). The contractor shall be licensed for the design and installation for the specific type of system in the jurisdiction where the work is to be performed and the State of Colorado. Upon request, submit evidence of such qualifications to the Engineer. Refer to Division-1 Section: "Definitions and Standards" for definitions for "Installers."

E. Qualifications for Welding Processes and Operators: Comply with the requirements of AWS D10.9, Specifications of Qualifications of Welding Procedures and Welders for Piping and Tubing, Level AR-3."

F. Regulatory Requirements: Comply with the requirements of the following codes:

1. NFPA 13 - Standard for the installation of Sprinkler System, including applicable seismic requirements.
2. NFPA 14 - Standard for the Installation of Standpipe and Hose Systems.
3. NFPA 24 - Installation of Private Fire Service Mains and their applications.
5. NFPA 1963 - Screw Threads and Gaskets for Fire Hose Connections.
6. UL and FM Compliance: All fire protection system materials and components shall be Underwriter's Laboratories and Factory Mutual listed as well as labeled for the application anticipated.
8. International Building Codes, including applicable seismic requirements.
9. Requirements of the local Building Department and Fire Department.
11. UL (Underwriters Laboratories) Fire Resistance Directory
12. UL Fire Protection Equipment Directory
13. Colorado Primary Drinking Water Regulations
15. NFPA-20
16. NFPA-25
17. NFPA-72
18. NFPA-214
19. NFPA-231
20. NFPA-231C
21. Other NFPA Standards as applicable
22. ANSI A-17.1, Safety Code for Elevators and Escalators
23. Colorado Dept. of Public Safety, Division of Fire Safety 8CCR 1507-11
24. Colorado Revised Statutes Section 24-33.5-1202 through 1208 (Senate Bill 90-4)

G. Reference and standards listed are minimum requirements. Where more stringent requirements are specified or noted on the drawings, this shall be applicable.

1.8 SEQUENCING AND SCHEDULING:

A. Schedule rough-in installations with installations of other building components.

B. Minimum time frame for notice of inspections, tests and meetings is five (5) days and list the persons to be notified.

1.9 EXTRA STOCK:

A. Heads: For each style and temperature range (and length for dry heads) required, furnish additional sprinkler heads per NFPA-13.

1. Obtain receipt from Owner that extra stock has been received.

B. Wrenches: Furnish 2 spanner wrenches for each type and size of valve connection and fire hose coupling.

PART 2 - PRODUCTS

2.1 MATERIALS AND PRODUCTS:

A. General: Provide piping materials and factory-fabricated piping products of sizes, types, pressure ratings, temperature ratings, and capacities as indicated. Where not indicated, provide proper selection as determined by Installer to comply with installation requirements. Provide sizes and types matching
piping and equipment connections; provide fittings of materials which match pipe materials used in fire protection systems.

B. All equipment used on this project shall be new and UL listed unless noted or specified otherwise.

2.2 MANUFACTURERS:

A. Manufacturer: Subject to compliance with requirements, provide fire protection system products from one of the following:

1. Gate Valves:
   a. Nibco
   b. Kennedy Valve, Div. of ITT Grinnell Valve Co., Inc.
   c. Mueller
   d. Stockham
   e. Milwaukee

2. Swing Check Valves:
   a. Central
   b. Mueller
   c. Kennedy Valve, Div. of ITT Grinnell Valve Co., Inc.
   d. Viking
   e. Victaulic
   f. Globe

3. Butterfly and Ball Valves:
   a. Nibco
   b. Victaulic
   c. Milwaukee
   d. Kennedy

4. Grooved Mechanical Couplings shall be greaseless type:
   a. Grinnell
   b. Victaulic Company of America
   c. Central Sprink, Inc.

5. Double Check Valve Assembly:
   a. Febco Model 850
   b. Watts Model 709
   c. Conbraco 40-100
   d. Ames Model 2000 (epoxy)

6. Fire Protection Specialty Valves (Dry and Preaction):
   a. Viking Corporation
   b. Central
   c. Globe

7. Fire Department Connection:
8. Sprinkler Heads:
   a. Reliable Automatic Sprinkler Co., Inc.
   b. Viking Corp.
   c. Globe
   d. Other manufacturers, if approved by the University as equal.

NOTE: Sprinklers that contain a synthetic, non-metallic o-ring are not acceptable.

9. Fire Protection Specialties:
   a. Croker-Standard Div; Fire-End & Croker Corp.
   b. Potter Roemer, Inc.
   c. Guardian Fire Equipment, Inc.

10. Inspector's Test and Drain Module
    a. Victaulic
    b. A.G.F.
    c. Grinnell/Gem

11. Alarm, Flow and Tamper Switches:
    a. Potter Electric Signal Corp.
    b. System Sensor
    c. Victaulic

2.3 BASIC IDENTIFICATION:

A. General: Provide identification complying with Division-21/22 "Mechanical Identification", in accordance with the following listing:

3. Fire Protection Signs: Provide the following signs:
   a. At each sprinkler valve, sign indicating what portion of system valve controls.
   b. At each outside alarm device, sign indicating what authority to call if device is activated.
   c. At door to each sprinkler control valves or at ceiling access points, sign reading "FIRE CONTROL".
   d. At each drain or test, sign indicating its purpose.

B. Attach to the riser a metal sign indicating the name, address and telephone number of the fire protection contractor. Also indicate the date of installation.
2.4 BASIC PIPING SPECIALTIES:

A. General: Provide piping specialties complying with Division-21/22 Basic Mechanical Materials and Methods section "Piping Specialties", in accordance with the following listing:

1. Pipe escutcheons.
2. Dielectric unions.
3. Drip pans.
4. Pipe sleeves.
5. Sleeve seals.
6. Fire Barrier Penetration Seals.

2.5 BASIC SUPPORTS AND ANCHORS:

A. General: Provide supports and anchors complying with Division-22 "Supports and Anchors" in accordance with the following listing:

1. Adjustable steel clevis hangers, adjustable steel band hangers, or adjustable band hangers, for horizontal-piping hangers and supports.
2. Two-bolt riser clamps for vertical piping supports.
3. Steel turnbuckles and malleable iron sockets for hanger-rod attachments.
4. Concrete inserts, top-beam C-clamps, side beam or channel clamps or center beam clamps for building attachments.
5. Concrete inserts and other type hangers penetrating into or through structural members shall be submitted (by the Fire Protection Contractor) to and have the approval of the structural engineer contracted for this project.
6. Powder driven studs shall not be allowed.
7. Hangers (which are acceptable for project) and hanger spacing shall be in accordance with NFPA-13.

2.6 PIPE & FITTINGS (UNDERGROUND):

A. Underground pipe shall be ductile iron, thickness Class 52 unless specified otherwise by local authorities or ANSI/AWWA C150/A21.50-81; 350 psi pressure rating; tar coated outside, cement mortar lined inside in accordance with ANSI/AWWA C104/A21.4-80. Full lengths of pipe shall be utilized to the greatest extent possible.

B. Fittings for ductile iron pipe shall be 250 psi pressure rating in accordance with ANSI/AWWA C110-77, tar coated outside and cement lined inside in accordance with ANSI/AWWA C104/A21.4-80.

C. Joints shall be push-on or mechanical type as per ANSI/AWWA C111/A21.11-80.

2.7 PIPE AND TUBING MATERIALS (INSIDE BUILDING):

A. General: Refer to Part 3 Article "Pipe Applications" for identification of systems where the below specified pipe and fitting materials are used.
B. Steel Pipe: ASTM A 53, A795 or A135, Schedule 40 or Schedule 10, U.S. manufacture, black steel pipe, plain ends. With **Antibacterial Formula™ (ABF)** or approved equal.

C. American Tube Company "Dyna-Thread-40" and "Dyna-Flow" and Allied Tube and Conduit Corporation "Super Flo" are acceptable alternates to Schedule 40 pipe. Installation shall be per manufacturer's recommendations.

D. Schedule 5 pipe shall not be allowed.

E. The Corrosion Resistance Ratio of the pipe shall be 1.00 or greater. Documentation shall be presented with product submittal.

F. Schedule 10 pipe shall only be allowed for pipe sizes 2-1/2 inches and larger.

G. Provide galvanized, schedule 40, piping system for preaction system and drain risers.

H. Pipe 2-1/2” and larger shall be cut-grooved for grooved fittings. Non-grooved pipes is not acceptable.

### 2.8 FITTINGS (INSIDE BUILDING):


B. Malleable-Iron Threaded Fittings: ANSI B16.3, Class 300, standard pattern, for threaded joints. Threads shall conform to ANSI B1.20.1. Install steel pipe with threaded joints and fittings for 2 inches and smaller and where shown on drawings.

C. Steel Fittings: ASTM A234, seamless or welded, for welded joints.

D. Grooved Mechanical Fittings: ASTM A 536, Grade 65-45-12 ductile iron; ASTM A 47 Grade 32510 malleable iron; or ASTM A53, Type F or Types E or S.

E. Grooved Mechanical Couplings: Consist of ductile or malleable iron housing, a synthetic rubber gasket of a central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure roll-grooved pipe and fittings. Grooved mechanical couplings including gaskets used on dry-pipe systems shall be listed for dry-pipe service.

F. Grooved Mechanical Fittings and Couplings for the entire fire protection system shall be of the same manufacturer as submitted in shop drawing equipment review.

G. Cast-Iron Threaded Flanges: ANSI B16.1, Class 250; raised ground face, bolt spot faced.

H. Cast Bronze Flanges: ANSI B16.24, Class 300; raised ground face, bolt holes spot faced.

I. Plain end, hooker type, or push-on fittings or couplings shall not be allowed.

J. Bushings and reducing couplings shall not be allowed.

K. UL listed and Factory Mutual approved segmentally welded fittings are acceptable. Friction loss and flow data shall accompany hydraulic calculations.

L. Threaded fittings shall be used in Architecturally exposed or sensitive areas.
2.9 JOINING MATERIALS:

A. Welding Materials: Comply with Section II, Part C, ASME Boiler and Pressure Vessel Code for welding materials appropriate for the wall thickness and chemical analysis of the pipe being welded.

B. Gasket Materials: Thickness, materials and type suitable for fluid or gas to be handled, and design temperatures and pressures.

2.10 GENERAL DUTY VALVES:

A. Gate Valves - 2 Inch and Smaller: Body and bonnet of cast bronze, 175 pound cold water working pressure - non-shock, threaded ends, solid wedge, outside screw and yoke, rising stem, screw-in bonnet, and malleable iron handwheel. Valves shall be capable of being repacked under pressure, with valve wide open.

B. Gate Valves - 2-1/2 Inch and Larger: Iron body; bronze mounted, 175 pound cold water working pressure - non-shock. Valves shall have solid taper wedge; outside screw and yoke, rising stem; flanged bonnet, with body and bonnet conforming to ASTM A 126 Class B; replaceable bronze wedge facing rings; flanged ends; and a packing assembly consisting of a cast iron gland flange, brass gland, packing, bonnet, and bronze bonnet bushing. Valves shall be capable of being repacked under pressure, with valve wide open.

C. Butterfly Valves: 2-1/2inches to 12inches, grooved, ductile iron body and disc ASTM-536, disc EPDM coated, listed and approved minimum 175 psi service, actuator, self-contained supervisory switch, weatherproof approved for indoor or outdoor use.

D. Ball Valves: 1-1/2inches and smaller shall be threaded, forged brass construction, with teflon seats and blow out proof stem. Ball shall be full port with stainless steel ball.

E. Ball Valves: 2inches to 3inches shall be listed to 300 p.s.i. with optional internal tamper switch. Body shall be ductile iron with corrosion resistant coating. Ball shall be 316 stainless steel, standard port design. 1-1/2" and Smaller: all bronze with screwed ends.

F. Swing Check Valves 2” and Larger: MSS SP-71; Class 175, cast iron body and bolted cap conforming to ASTM A 126, Class B; horizontal swing, with a bronze disc or cast iron disc with bronze disc ring, and flanged ends. Valve shall be capable of being refitted while the valve remains in the line.

G. Double Check Valve Assembly: Double check valve assembly shall be UL listed for fire protection service and USC-CCCF approved. Installation arrangement shall be per manufacturer's recommendations.

H. Reduced Pressure Backflow Preventer:

1. Reduced pressure backflow preventers shall be used for fire suppression systems only when chemical additives such as antifreeze are present or when untreated water may be pumped into the system.

I. Preaction Valves:

1. The valve assembly including the valve, trim packages and actuation system shall be FM approved as a complete assembly.

2. The preaction valve shall be actuated and sequenced as noted in section 1.04-C.4.
3. The size of the preaction valve shall be established via the hydraulic calculations and be supplied by a pipe of an equal or larger size. The valve shall be rated for a one-hundred seventy-five (175) psi working pressure. The basic valve trim shall include manual control/activation capability, drain and test provision with trim for automatic operation via a 24 volt solenoid (to be provided under this section). Valve shall be wired normally closed or as otherwise specified by the manufacturer. The manual release switches, whether mechanical or electrical, shall be located at the exits from the protected area. Coordinate work with Division 26 when necessary.

J. Solenoid Release Valves:
   1. Shall be specifically listed/approved for use in fire protection systems.
   2. Shall be FM approved as compatible with the preaction valve and fire alarm control panel.

2.11 SPECIALTY VALVES:

A. Dry-Pipe Valves: Differential type, 175 psig working pressure, and have cast iron, flanged inlet and outlet, bronze seat with "O" ring seals, single hinge pin and latch design. Provide trim sets for air supply, drain, priming level, alarm connections, ball drip valves, pressure gauges, priming chamber attachment and fill line attachment. For low differential valves, a high water level signaling device or automatic drain shall be provided.

B. Air (Nitrogen) Pressure Maintenance Device, Dry-Pipe Systems: An automatic device to maintain the correct air pressure in a dry-pipe system or deluge system. System shall have shut-off valves to permit servicing without shutting down the sprinkler system, bypass valve for quick system filling, pressure regulator or switch to maintain system pressure, strainer; pressure ratings 14 to 60 psig adjustable range, and 175 psig maximum inlet pressure. Electrical ratings shall match compressor ratings.

C. Preaction Valves: Preaction systems shall have valves specifically listed for preaction service.

D. Preaction System Control Panel: Panels shall be single area, two area, or single area cross zoned type as indicated. Control panel shall consist of a NEMA 1 enclosure, and contains detector, alarm and solenoid valve circuitry for operation of deluge valves. Panels shall contain power supply, battery charger, standby batteries, field wiring terminal strip, electrically supervised solenoid valves and polarized fire alarm bell, lamp test facility, SPDT auxiliary alarm contacts and rectifier. Control panel shall be UL listed and FM approved when used with thermal detectors and Class A detector circuit wiring. Electrical characteristics shall be 120 volts AC, 60 Hz, with 24 volts DC Gel Cell batteries. Panel provided by Division 21. Wiring from Fire Alarm Panel and power to Control Panel by Division 26. Locate Control Panel along side Fire Alarm Panel.

2.12 BASIC METERS AND GAUGES:

A. General: Provide meters and gauges complying with Division- 22 "Meters and Gauges", in accordance with the following:

   1. Water Pressure
      a. Brass bourdon tube with 3-1/2" diameter case rated for three-hundred (300) psi water pressure.
      b. Gauge Dial: From 0-300 psi in 5# increments.
      c. Equip gauges with a 1/4" stem with a 1/4" shut-off valve.

   2. Air (Nitrogen) Pressure
a. Brass bourdon tube with 3-1/2" diameter case rated for two-hundred fifty (250) psi air pressure.

b. Gauge Dial: From 0-100 psi in 1 psi increments.

c. Equipped gauges with a 1/4" stem with a 1/4" shut-off valve.

2.13 ALARM DEVICE AND FIRE PROTECTION SPECIALTIES:

A. General: Provide fire protection specialties, UL-listed, in accordance with the listing. Provide sizes and types which mate and match piping and equipment connections.

B. Water Flow Indicators: Vane type water flow detector, rated to 250 psig; designed for horizontal or vertical installation; have 2-SPDT circuit switches to provide isolated alarm and auxiliary contacts, 7 ampere 125 volts AC and 0.25 ampere 24 volts DC; capable of being wired in normally open position; with self reset capabilities; complete with factory-set field-adjustable retard element to prevent false signals, tamper-proof cover which sends a signal when cover is removed, and with activation time retarding capability set at 30 seconds. The setting shall be verified through the inspector's test prior to final inspection.

C. Supervisory Switches: Provide products recommended by manufacturer for use in service indicated. SPST, normally closed contacts, designed to signal valve in other than full open position. Capable of being wired in NO/NC position, and shall have automatic reset capabilities. Minimum contact rating shall be 0.25 A @ 24V DC.

D. Low Pressure Supervisory Switches:

1. A low pressure alarm switch shall be provided for dry pipe sprinkler systems and supervised preaction sprinkler systems. The switches shall meet the following requirement:

   a. Compatible with the equipment used.
   b. ½" NPT enclosure.
   c. NEMA 1 enclosure
   d. Capable of detecting a ten (10) psi decrease in normal pressure and be adjustable.
   e. Tamper proof
   f. Capable of operating at 24 VDC or as specified by the manufacturer.

E. Pressure Switch: Indicating low pressure trouble in sprinkler system.

F. Pressure switch: Indicating flow in sprinkler system.

G. Low Nitrogen Pressure Horn: Provide low air pressure horn as indicated.

H. Exterior Alarm Signals:

1. Shall mount above the fire department connection at a height of ten (10) to fifteen (15) feet above adjacent grade.

2. Where a FACP is available; an exterior electric bell with flashing strobe, as specified in Section 16720 powered by the FACP having a minimum audible level of 85dBA at ten (10) feet. This work shall be coordinated with Division 26.

3. When approved by AHJ, a water motor gong with a minimum six (6) inch diameter shall be provided for sprinkler systems which are installed where there are no fire alarm panels capable
of monitoring the required signals. The water gongs shall be used in construction with an alarm check valve.

I. Nitrogen Maintenance Device:

1. Listed/approved for the service intended.
2. Automatic and field adjustable.
3. Shall be of the high pressure reducing type.

2.14 AUTOMATIC SPRINKLERS:

A. Sprinkler Heads: Fusible link or frangible bulb type, and style as indicated or required by the application. Unless otherwise indicated, provide heads with nominal 1/2 inch discharge orifice, for "ordinary" temperature range with a minimum temperature of 155 degrees F. Provide "intermediate" temperature heads in Electrical and Mechanical rooms, where required as noted in NFPA 13, and as required by the Authority having jurisdiction. Use of quick response heads is strongly encouraged where arrowed.

B. Sprinkler Head Finishes: Provide heads with the following finishes:

1. Upright, Pendent and Sidewall Styles: Factory brass, rough bronze finish for heads in unfinished spaces. Heads shall be stainless steel where installed exposed to acids, chemicals, or other corrosive fumes.
2. Recessed Style: Bright chrome, with bright chrome escutcheon plate. GEM Models FR948 and F948 recessed sprinklers are not acceptable.
3. See drawings for additional sprinkler type requirements.

C. Sprinkler Head Cabinet and Wrench: Finished steel cabinet, suitable for wall mounting, with hinged cover and space for spare sprinkler heads plus sprinkler head wrench. Provide amounts of each style per NFPA-13. Locate head cabinet on shop drawing submittal. Where temperature will not exceed 100°F, and indicate location.

D. Plastic fire sprinkler escutcheons are not acceptable.

2.15 FIRE HOSES AND RACKS:

A. Hose Outlet Valves: 300 psig, 2-1/2 inch, rough chrome plated, pressure regulating. brass angle valve, with removable, 2-1/2 inch x 1-1/2 inch reducing lug pin and hose connector coupling. Valve and coupling shall have external threads having the local fire department standard thread, for the 2-1/2 inch valve, as specified in NFPA 1963. Provide spanner wrench for removal of reducing coupling. Provide with cap and chain finished to match valve.

1. Concealed hose valves within a building shall be accessible by the use of a single key. This keying shall match keying which is used to access system control valves.

2.16 HOSE, VALVE AND EXTINGUISHER CABINETS:

A. General: Provide cabinets to house hose valves and extinguishers as indicated.
B. Construction: Manufacturer's standard enameled steel box, with trim, frame, door and hardware to suit
cabinet type, trim style, and door style indicated. Weld all joints and grind smooth. Miter and weld
perimeter door frames.

C. Cabinet Type: Suitable for mounting conditions indicated, of the following types:

1. Recessed (FVC-1): Cabinet box (tub) fully recessed in walls of sufficient depth to suit style of
   trim indicated.

2. Surface-Mounted (FVC-2): Cabinet box (tub) fully exposed and mounted directly on wall.

D. Provide fire valve cabinet of type indicated with full glass panel door.

E. Provide standard equipment "Croker" Series 2750, or "Potter Roemer" Series 1880 valve and
   extinguisher cabinets.

2.17 ROOF MANIFOLD:

A. Provide 2 way cast brass angle body, male outlets. Provide with 2 hose angle valves (2-1/2inch), cast
   brass body, female inlet x male outlet, caps and chains, 300 psig rated. Manifold and valves shall have
   rough brass finish.

2.18 FIRE DEPARTMENT CONNECTIONS:

A. Sidewalk Siamese Connection: Polished Chrome plated cast brass, angle body, two way, siamese
   connection. Connection sizes shall be 4 inch outlet and two 2-1/2 inch inlets, having NH standard
   threads, for the connection size indicated, as specified in NFPA 1963. Each inlet shall have a clapper
   valve, and cap and chain. Provide 18 inch high chrome plated brass sleeve and chrome plated brass
   sidewalk plate, with words "Standpipe - Fire Dept. Connection" or "Auto Spkr. - Fire Dept.
   Connection" or "Auto Spkr. and Standpipe - Fire Department Connection" in raised letters.

B. Fire department connections including location shall meet the approval of the fire department having
   jurisdiction.

C. Where more than one fire department connection is used for the sprinkler system in a building, they
   shall be interconnected so that the entire sprinkler system is fed by each of the fire department
   connections.

2.19 INSPECTOR'S TEST AND DRAIN ASSEMBLY:

A. Provide an alarm test module of a manufacturer listed in paragraph 2.2.

B. Comply with NFPA-14, Section 5-11, for draining and testing of wet standpipe system.

C. Test and drain piping shall be routed to exterior. Location shall meet Owner's approval.

PART 3 - EXECUTION

3.1 SPECIFIC DESIGN PARAMETERS

A. General:

1. The “Room Design Method” and “Small Room Rule” shall not be used in the design of systems
   unless otherwise deemed necessary by engineer and accepted by AHJ.
2. Architect/Engineer shall determine which hydrants to test in consultation with the AHJ.

3. Water supply flow test(s) shall be conducted by the contractor and witnessed by the AHJ. Test(s) shall be conducted in strict accordance with NFPA #13 and NFPA #291. The City of Boulder Fire Department shall be invited to witness the test(s). Notify the City of Boulder Water Department of the time and location of the test(s) prior to operating hydrants. Procedures specific to each project including location, date and time shall be submitted to the AHJ for approval two weeks prior to conducting tests. Such tests may discolor water supply to buildings during the test. As such, if the test date or time coincides with uninterruptible Campus functions, such as research, the owner reserves the right to delay or otherwise reschedule the test.

4. Sprinkler systems protecting buildings classified as Ordinary Hazard shall not be connected to a 6” dead-end type supply main if the main also supplies a fire hydrant. The minimum size supply main shall be 8” for this situation (from the looped main to the hydrant).

B. Hydraulic Calculations:

1. Flow velocity in underground water mains shall not exceed sixteen (16) feet per second. Velocity in above ground sprinkler system piping shall not exceed twenty (20) feet per second.

2. Pipe sizes shall be calculated so that the combines sprinkler and standpipe system (plus domestic demand) leave a safety factor of 10 psi; see 1.04-A.6.

3. The hydraulic calculations shall be calculated back to a looped water main and be based on the available water supply flow test results. In the case of dead-end type mains, calculations shall include piping to the point where the flow test is effective.

4. The hydraulic calculations shall prove the hydraulically most remote and demanding areas of not less than 1,500 sq. ft., to allow for flexibility in building use, i.e., Room Design Method of NFPA 13 may not be used. Velocity pressure may be neglected in the hydraulic calculations. This may involve submitting auxiliary hydraulic calculations to prove that the most remote and demanding area was calculated. See item 3.01-A.1, above.

NOTE: Allowable reductions of the system’s area of operation for the Area/Design Method from NFPA 13 are acceptable and encouraged.

5. Hydraulic calculation submittals shall clearly define and annotate all devices which will cause friction loss with equivalent lengths of pipe. This includes vane type electric water flow switches (assume 10 feet of equivalent length of pipe).

6. Inside Hose Streams:

   a. For combined standpipe/sprinkler systems, standpipe demands are added to the sprinkler system demand at the point(s) of connection.

   b. For Class I standpipe systems not supplied through a sprinkler system, the minimum demand shall comply with NFPA #14.

C. Fire Protection System(s) Design Requirements:

1. Piping C-factors for new, steel piping, above ground and underground shall be120.

2. Maximum Sprinkler Head Spacing for Light Hazard, Ordinary Hazard and Extra Hazard occupancies shall be per NFPA 13.
3.2 PREPARATION:

A. Any system piping or components which are installed, purchased or fabricated prior to the Contractor receiving a set of approved shop drawings, shall be the responsibility of the Contractor.

B. System installation shall not commence until the Contractor has obtained required approval of shop drawings.

C. Contract drawings are diagrammatic in character and do not necessarily indicate every required offset, valve, fitting, etc.

D. Contract drawings and specifications are complementary. Whatever is called for in either is binding as though called for in both. The most restrictive requirements shall be applied.

E. Contract drawings shall not be scaled for rough-in measurements or used as shop drawings. Where drawings are required for these purposes or have to be made from field measurements, contractor shall take necessary measurements and prepare the drawings.

F. Before any work is installed, determine that equipment will properly fit the space; that required piping grades can be maintained without interferences between systems, with structural elements or with the work of other trades.

G. Coordinate the installation of fire protection materials and equipment above and below ceilings with suspension system, light fixtures and other building components.

1. Coordinate ceiling space carefully with all trades. In the event of conflict, install fire protection and electric systems within the cavity space allocation in the following order:
   a. Fire sprinkler mains and cross mains.
   b. Electrical conduit
   c. Fire sprinkler branch line piping.

H. Verify all dimensions by field measurement.

I. Arrange for chases, slots and openings in other building components to allow for fire protection installations.

J. Sequence, coordinate and integrate installations of fire protection materials and equipment for efficient flow of the work.

K. Coordinate the cutting and patching of building components to accommodate the installation of fire protection equipment and materials.

L. Where mounting heights are not detailed or dimensioned, install overhead fire protection services and equipment to provide the maximum headroom possible. Notify Engineer and Owner of any conditions where headroom of less than 7’-4” will result.

M. Install fire protection equipment to facilitate maintenance and repair or replacement of equipment components. Connect equipment for ease of disconnecting and to allow minimum interference with other installations.

3.3 PIPE APPLICATIONS:

A. Install Schedule 40 steel pipe with threaded joints and fittings for 2 inch and smaller.
3.4 PIPING INSTALLATIONS:

A. General: Any damages resulting from the failure of any new system components shall be replaced at no cost to the Owner.

B. Provide a minimum 5 feet-0 inches cover for all underground pipe installations. Install in accordance with AWWA C600.

C. Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate the general location and arrangement of piping systems. So far as practical, install piping as indicated. Drawings are diagrammatic in character and do not necessarily indicate every required offset, valve, fitting, etc.
   
   1. Deviations from approved "working plans" for sprinkler piping, require written approval of the authority having jurisdiction. Written approval shall be on file with the Engineer prior to deviating from the approved "working plans."
   
   2. Slope piping in dry and preaction systems to facilitate drainage to point of supply.

D. Install sprinkler piping to provide for system drainage in accordance with NFPA 13.

E. Use approved fittings to make all changes in direction, branch takeoffs from mains, and reductions in pipe sizes. Welded outlet branch pipe fittings are acceptable.

F. Install unions in pipe 2 inch and smaller, adjacent to each valve. Unions are not required on flanged devices or in piping installations using grooved mechanical couplings.

G. Install flanges or flange adapters on valves, apparatus, and equipment having 2-1/2 inch and larger connections.

H. For welded pipe, all cutouts (coupons) shall be removed prior to installation.
   
   1. The end of each cross main shall be equipped with a minimum of 1-1/4” threaded capped connections to facilitate plenum. Install per NFAP 13 requirements.

I. Hangers and Supports: Comply with the requirements of NFPA 13. Hanger and support spacing and locations for piping joined with grooved mechanical couplings shall be in accordance with the grooved mechanical coupling manufacturer's written instructions, for rigid systems. Provide protection from damage where subject to earthquake in accordance with NFPA 13.

J. Make connections between underground and above-ground piping using an approved transition piece strapped or fastened to prevent separation.

K. Install mechanical sleeve seal at pipe penetrations in basement and foundation walls. Refer to Division 22 Section "Basic Piping Materials and Methods."
   
   1. The system riser shall not be attached to the supply connection until the underground piping is flushed, tested and accepted by the AHJ. The two week notice requirements and rescheduling conditions, as stated under section 3.01-A.3 is applicable.

L. All piping penetrating walls to structure shall be sleeved and sealed per division 22/23.
M. Install test connections sized and located in accordance with NFPA 13 complete with shutoff valve. Test connections may also serve as drain pipes.

N. Install pressure gauge on the riser or feed main at or near each test connection. Provide gauge with a connection not less than 1/4 inch and having a soft metal seated globe valve, arranged for draining pipe between gauge and valve. Install gauges to permit removal, and where they will not be subject to freezing.

O. The fire line entry valves shall have monitoring electrical switches, the wiring from which shall be carried to the fire annunciating panel.

P. The fire protection contractor shall be responsible for the coordination of his installation with all other contractors. See Section 21 05 00 for prioritized components.

Q. Protect adjacent area where pipe cutting and threading takes place (e.g. floors, ceilings, walls, etc.).

R. There shall be no fire sprinkler piping in electrical rooms (other than piping serving sprinklers directly in that room) or installed over any electrical panels.

S. Provide spring-loaded check valve at top of drain risers.

T. Install pressure gauges on city and system sides of fire entry valve assembly.

U. Install hangers straight and true and piping parallel to building lines.

V. Powder driven hangers shall not be used without prior AHJ approval.

### 3.5 PIPE JOINT CONSTRUCTION:

A. Welded Joints: AWS D10.9, Level AR-3.

B. Threaded Joints: Conform to ANSI B1.20.1, tapered pipe threads for field cut threads. Join pipe, fittings, and valves as follows:

1. Note the internal length of threads in fittings or valve ends, and proximity of internal seat or wall, to determine how far pipe should be threaded into joint.

2. Align threads at point of assembly.

3. Apply appropriate tape or thread compound to the external pipe threads.

4. Assemble joint to appropriate thread depth. When using a wrench on valves place the wrench on the valve end into which the pipe is being threaded.

5. Damaged Threads: Do not use pipe with threads which are corroded or damaged. If a weld opens during cutting or threading operations, that portion of pipe shall not be used.

C. Flanged Joints: Align flange surfaces parallel. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly to appropriate torque specified by the bolt manufacturer.

D. Mechanical Grooved Joints: Cut grooves on pipe ends dimensionally compatible with the couplings.

E. End Treatment: After cutting pipe lengths, remove burrs and fins from pipe ends.
3.6 VALVE INSTALLATIONS:

A. General: Install fire protection specialty valves, fittings and specialties in accordance with the manufacturer's written instructions, NFPA 13 and the authority having jurisdiction.

1. Riser Control Valve
   a. Rooms or enclosures housing sprinkler system control valves shall be equipped with adequate heating, lighting and adequate clearance.
   b. System control valves shall be made accessible and operable from the floor, unless otherwise determined by the Engineer and agreed upon by the AHJ in writing.

B. Gate Valves: Install electronically supervised-open indicating valves so located to control all sources of water supply except fire department and roof manifolds connections. Where there is more than one control valve, provide permanently marked identification signs indicating the portion of the system controlled by each valve. Refer to Division-15 Section "Mechanical Identification" for valve tags and signs.

C. Valve at water main tap shall be underground gate valve with roadway box.

D. Install approved check valve assembly backflow preventer in each water supply connection. Provide check valve and indicating valve (with tamper switch) on the discharge side of reduced pressure backflow preventers.

E. Dry-Pipe Valves: Install in the vertical position, at 24 to 48 inches A.F.F. in proper direction of flow, in the main supply to the dry-pipe system. The valve shall be located within an artificially lighted and head enclosure. Install the basic trim set, priming chamber attachment and fill line attachment in accordance with the manufacturer's written instructions. During hydrostatic test of system piping at pressure in excess of 50 psi, position the clapper in latched wide open position or removed from valve, to prevent injury to the valve. Test valve for proper operation.

F. Hose Outlet Valves: Install 2-1/2 inch hose outlet valves with easily removable 2-1/2 to 1-1/2 inch reducing coupling at each standpipe outlet for hose connections.

G. Fire Hose Valves:
   1. Fire department hose valves shall be installed no lower than 3'-6" above the finished floor or no higher than 5'-0" above the finished floor level.
   2. Fire hose valves located in cabinets shall be arranged so that the outlet points outward perpendicular (90 degrees) from the wall, the outlet projecting from the midpoint of the total height of the cabinet and a minimum of six (6) inches shall be maintained between the cabinet walls and the outlets. Hose valves shall be installed so that the handle is no closer than 1-182” to a wall or cabinet wall.
   3. The location of standpipe hose valve and fire extinguisher cabinets shall be identified as follows:
      a. The inner panel of the cabinet shall be painted with red reflective paint.
      b. Red and white reflective tape shall be installed on the exterior of the cabinets on the sides or side molding.
   4. Concealed locations of all hose valves shall be identified by signs on all doors which shall be passed through to gain access to valve locations from the nearest common area corridor. For signs see section 3.03-H-4.
H. Drain and Test Valves

1. If the fire protection piping is located at a lower elevation than the adjoining building, an outside drain installed to conduct main drain tests and a system auxiliary drain piped to a floor drain is desirable. An extra valve installed on the system drain piping maybe necessary in order to isolate the system drain during tests of the two (2) inch main drain.

   NOTE: Engineer to determine

2. Auxiliary drains and valves shall be provided as required by NFPA 13.

3. Sight glasses shall be provided on all inspectors test connections where discharge cannot be seen while valves are operated.

4. The inspector’s test connection, where required, shall terminate at a fort-five (45) degree elbow with a sprinkler which has the frame and strut assembly removed; other restricted orifices listed for the same purpose are acceptable. These shall be piped to the building exterior at grade level. If installed on the building interior, it shall include a restricting orifice and discharge to an acceptable drain with adequate capacity. The orifice size shall be the same as the smallest sprinkler installed on the system.

5. All drains located inside the building, shall be piped to the outside of the building at a point free from causing water damage, terminating with a forty-five (45) degree elbow. This includes the drain for the fire department connection piping. (Exception: Auxiliary drains).

6. Contractor shall supply and install a concrete splash block with a minimum length of four (4) feet to direct the drain or test discharge water so as not to disturb adjacent landscape.

7. All shut-off, drain and test valves which are placed in concealed spaces shall have the standard sign affixed in a visible location; see section 3.03-H. For example, if a valve is located above a ceiling, a sign indicating the location and type of valve shall be located on the wall, immediately below the ceiling.

8. Drain valves shall be made accessible and operable from floor unless otherwise proposed by the engineer and accepted by AHJ in writing.

I. Preaction Valves:

1. Adequate clearance shall be provided to facilitate maintenance.

2. Valve shall be adequately supported.

3. Engineer shall indicate valve location on drawings to allow for adequate draining of the system.

4. Valve shall be located within an artificially lighted and heated enclosure.

5. Valve shall be installed in the vertical position at twenty-four (24) to forty-eight (48) inches above the finished floor.

3.7 SPRINKLER HEAD INSTALLATIONS:

A. Any sprinkler heads with any paint on them shall be replaced. The sprinkler system shall then be hydrostatically tested again at the contractor's expense.

B. Sprinkler heads shall be positioned so as to comply with NFPA-13 for any obstructions. This includes, but is not limited to, soffits, surface mounted lights and indirect lighting arrangements. The Fire
Protection Contractor is responsible for identifying these obstructions and designing the system accordingly.

C. Run piping concealed above heated furred ceilings and in joists to minimize obstructions. Expose only heads.

D. Protect exposed sprinkler heads against mechanical injury with standard guards. Provide sprinkler head guards in all mechanical, electrical or storage rooms as well as exposed pendant heads which are installed less than 8 feet 0 inches A.F.F.

E. Provide 1 inch diameter nipple and 1 inch x 1/2 inch reducing fitting for each upright head. (Excluding mechanical equipment rooms.)

F. Provide heads in "pocketed" areas caused by exposed duct, piping or beams.

G. Sprinkler head deflector distance from face of finished ceiling shall not exceed 4 inches.

H. Sprinkler heads shall be located in the center of all 2 foot x 2 foot ceiling tiles and quarter points, along the center line lengthwise of 2 foot x 4 foot ceiling tiles.

I. Use proper tools to prevent damage during installations.

J. Install sprinkler piping in a manner such that mechanical equipment, ceiling tiles or lights can be accessed and easily removed. The sprinkler piping shall be installed to provide a minimum of 6 inches above the top of a finished ceiling.

K. Minimum fire sprinkler head temperature rating for sprinklers in electrical rooms shall be 212 degrees F. Keep sprinklers as far from transformers and/or panels as spacing allows.

3.8 FIRE VALVE CABINET INSTALLATIONS:

A. Install fire hose valve and extinguisher cabinets in locations and at mounting heights indicated, or if not indicated, at heights to comply with applicable regulations of governing authorities.

1. Prepare recesses in walls for cabinets as required by type and size of cabinet and style of trim and to comply with manufacturer's instructions.

2. Securely fasten fire hose valve and cabinets to structure, square and plumb, to comply with manufacturer's instructions.

3. Where exact location of surface-mounted cabinets is not indicated, locate as directed by Architect.

B. Identify equipment in cabinet with lettering spelling "Fire Hose," "Fire Hose and Extinguisher," and "Fire Hose Valve and Extinguisher" applied to door by process indicated below. Provide lettering to comply with requirements indicated for letter style, color, size, spacing and location or, if not otherwise indicated, as selected by Architect from manufacturer's standard arrangements.

3.9 FIRE DEPARTMENT CONNECTION INSTALLATIONS:

A. Install automatic drip valves at the check valve on the fire department connection to the mains, route drain to exterior.

B. Install mechanical sleeve seal at pipe penetration in outside walls.
C. Siamese connections serving the same building shall be interconnected so that each one charges all systems.

D. Electrical Equipment:

1. Tamper switch signals shall initiate a unique supervisory alarm signal at the building FACP.

2. Other system supervisory signals shall provide unique indications of system supervisory status.

3. An exterior electric bell with flashing strobe assembly shall be installed for each system at a minimum height of ten (10) feet or maximum fifteen (15) feet above adjacent grade, above the fire department connection serving the sprinkler system; coordinate with Division 26.

4. If an existing exterior warning signal exists, re-use of the device will depend on the Owners approval as to its condition and location. If reused, contractor shall be responsible for its proper operation.

3.10 ROOF MANIFOLD INSTALLATION:

A. Install automatic drip valves between control valve and roof manifold outlets as to drain entire length of pipe, route drain to Janitor's sink.

B. Install mechanical sleeve seal at pipe penetration thru roof. Seal penetration water tight.

3.11 TEMPORARY CONSTRUCTION STANDPIPE SYSTEMS:

A. Temporary construction of standpipe risers shall be provided, along with hose, nozzles and valves as appropriate in accordance with IBC 3311. The risers shall continue up thru each floor as the floors are erected. Standpipes shall be supplied through a temporary Siamese inlet at grade located and sized according to IBC 3311 and IBC 905. Access to the temporary Siamese inlet connection shall be kept clear and accessible at all times. It shall be the responsibility of the Contractor to insure this temporary fire protection supply be available at all times. All valves shall be properly adjusted for the maximum pressure setting allowable.

B. The contractor shall be responsible for all design coordination and approval with the Authority Having Jurisdiction, construction and phasing of the temporary construction standpipe system.

3.12 IDENTIFICATION SIGNS:

A. Signs shall be permanently marked and constructed of weather-proof metal or rigid plastic.

B. Signs shall be secured to a device or the building wall with substantial and corrosion-resistant chains or fasteners.

C. Where sprinkler or standpipe control valves, test locations, or dry-pipe auxiliary drains are located in a room, above the ceiling, or in a concealed space, the location of the valve shall be indicated by a 2” x 6” sign. Signs shall be located as follows:

1. If a valve is located inside a room, a sign shall be placed above the door tight to the door jam directly above the door handle. Similar signs are required on all intermediate doors within rooms.

2. If a valve is located above the ceiling, a sign shall be placed directly under the access panel or proper ceiling tile to access valve. Sign shall be tight to ceiling.
3. In other locations, AHJ shall be contacted for specific direction of sign placement.

D. Signs used to identify the location of fire hose valves, in a closet, shall be a minimum of 1’ x 2’ and have letter with a two (2) inch height and 1/4” stroke.

E. Valves:
   1. All control, drain and test connection valves shall be identified in accordance with NFPA 13.
   2. All main and sectional system control valves, including water supply control valves, shall have a sign indicating the portion of the system controlled by the valve.

F. Where sprinkler piping is supplied by a system with more than one system riser, a sign shall be located at each dual or multiple feed combination system riser to identify that to isolate the sprinkler system served by the control valve, an additional control valve or valves at other locations shall be shut off. The sign shall identify the location of the additional control valves.

G. Fire Department Connections:
   1. Each fire department connection shall be designated by a sign having raised letters at least 1 inch in height cast on a plate or fitting indicating service design, e.g., “AUTO SPKR.”, “AUTO SPKR. AND STANDPIPE”.
   2. For manual/dry standpipe a sign shall be provided stating “MANUAL STANDPIPE FOR FIRE DEPARTMENT USE ONLY”. A sign is also to indicate the pressure required at the inlets to deliver the system demand.
   3. Where a fire department connection services only a portion of a system or building, a sign shall be attached indicated portions of the building served.

H. The installing contractor shall provide a sign identifying the design basis of a system as hydraulic calculations or pipe schedule. The sign shall be located at the water supply control valve for sprinkler or standpipe systems.

I. For buildings without central station reporting, an approved identification sign should be provided for outside alarm devices in accordance with NFPA 13: A-4-6.1.1, which will state:

   “SPRINKLER FIRE ALARM – WHEN BELL RINGS CALL 911”.

3.13 INSTALLATION OF METERS AND GAUGES:

A. Install meters and gauges in accordance with Division-23 "Meters and Gauges".

3.14 PROJECT COORDINATION:

A. Welding, cutting and other Hot Work:
   1. Cutting or of pipes using heat/ignition generating devices shall not be conducted inside any portion of existing buildings without written approval from the University. Follow the University Central Station and Hot Work Permit Procedures. Welding of pipes on-site is prohibited by NFPA 13 and only shop welding shall be allowed. Brazing and soldering of copper tubes shall not be conducted within the buildings prior to application and acceptance of hot work permits.
3.15 FIELD QUALITY CONTROL:


B. The fire sprinkler system shall not be connected to underground piping until the fire service main is tested and approved.

C. The Fire Protection Contractor shall conduct and bear the costs of all necessary tests of the fire protection work, furnish all labor, power and equipment. All piping shall be tested with water as required, the tests witnessed by the authority having jurisdiction.

D. Only DowFrost (Propylene Glycol with inhibitor) antifreeze agent shall be used in antifreeze sprinkler systems.

E. Antifreeze systems shall be hydrostatically tested prior to introducing antifreeze solution into the system.

F. For retrofit installations, a pneumatic test with a maximum pressure of forty (40) psi shall be conducted prior to a hydrostatic test to avoid any water damage due to leaks. This test does not replace the hydrostatic test.

G. Dry and Preaction System Tests:
   1. All testing requirements for wet pipe systems in this section shall be conducted.
   2. A Nitrogen test shall be performed as follows:
      a. Nitrogen pressure of forty (40) psi shall be maintained for twenty-four (24) hours without losing more than 1-1/2 psi during the test period when the system is required to maintain nitrogen pressure.
   3. A functional test shall be conducted on all detection devices, valves and drainage facilities for preaction and dry systems.
      a. Maximum dry valve trip time shall be fifteen (15) seconds from the time the inspectors test valve is completely open.
      b. Maximum water delivery time to the inspectors test for dry systems shall be sixty (60) seconds from when the inspectors test valve is completely open.
   4. Dry standpipe system piping shall be hydrostatically tested at fifty (50) psi above the maximum street pressure.
   5. After a functional test of a dry or preaction valve, if required by valve type, the valve assembly cover plate shall be removed to verify proper valve operation.

H. Dry and preaction systems shall be both hydrostatically and pneumatically tested. Pneumatic test shall be in accordance with NFPA-13.

I. All fire protection piping, including air supply pipe to the Fire Department connection, shall be tested under a hydrostatic pressure of not less than 200 psig, for a duration of not less than 2 hours.
J. Replace piping system components which do not pass the test procedures specified, and retest repaired portion of the system at Fire Protection Contractor's expense.

K. All piping tests (pneumatic and hydrostatic) shall be conducted prior to the application of any painting materials. This will prevent hidden leaks and/or repainting of repaired/altered piping.

3.16 **SYSTEM CERTIFICATION:**

A. The Contractor shall provide the Owner with written certification prior to final inspection, that all new equipment:

1. Has been visually inspected and functionally tested as required by the Specifications.

2. Is installed entirely in accordance with the manufacturer's recommendations within the limitations of the system's UL listings and NFPA criteria.

3. Is in proper working order.

3.17 **FINAL INSPECTION AND TESTING:**

A. The Contractor shall make arrangements with the Owner for final inspection and witnessing of the final acceptance tests. The Fire Protection Contractor, the Alarm System Contractor, Engineer and the Owner will conduct the final inspection and witness the final acceptance test.

B. All tests and inspections required by the referenced Codes and Standards, and the Owner shall be performed by the Contractor.

C. The inspecting committee as referenced above will visit the job site to inspect the work and witness the final acceptance tests when they have been advised by the Contractor that the work is completed and ready for test. If the work is not complete or the test is unsatisfactory, the Contractor shall be responsible for the Consultant's extra time and expenses for re-inspection and witnessing the re-testing of the work. Such extra fees shall be deducted from payments by the Owner to the Contractor.

D. After the system has been inspected and tested, a certificate, "Contractor's Material and Test Certificate Sprinkler System - Water Spray System," shall be provided by the contractor and shall be signed by him or his representative, the Owner's representative and by a representative of the fire department if appropriate. Sufficient copies shall be prepared to ensure the Engineer, Owner, all inspecting authorities and the contractor have a copy for their files. The Contractor shall prepare one (1) test report for each inspection performed whether successful or not.

E. The signing of the certificate by the Owner's representative shall in no way prejudice any claim against the contractor for faulty material, poor workmanship, or failure to comply with inspecting authority's requirements or local ordinances.

F. Contractor shall provide at least five (5) working days notice for all tests. 48 hour notice is required for cancellations, or it shall be considered a re-inspection.

G. All sprinkler supervisory initiating devices shall be functionally tested to verify proper operation.

H. All supervisory functions of each initiating device shall be functionally tested.

I. Receipt of all alarm and trouble signals, initiated during the course of the testing, shall be verified at the fire alarm control panel.
3.18 WORK BY OTHERS:

A. Wiring of all water flow switches and tamper switches on valves to central alarm panel are by Division 26.

3.19 OPERATION AND MAINTENANCE MANUAL:

A. The Contractor shall provide the Owner with a loose-leaf manual containing:

1. A detailed description of the systems.

2. A detailed description of routine maintenance required or recommended or which would be provided under a maintenance contract including a maintenance schedule and detailed maintenance instructions for each type of device installed.

3. One copy of NFPA-25.

4. Manufacturers' data sheets and installation manuals/instructions for all equipment installed.

5. A list of recommended spare parts.

6. Service directory, listing the specific equipment items and where parts can be obtained, with name, address and telephone number.

7. Full size sepias of the record drawings (stamped and signed per section 1.6).

8. Hydraulic calculations (stamped and signed per section 1.6).


B. Refer to Division 1 for additional requirements.

C. Within 15 days of the completion of the work, six (6) copies of the manual shall be submitted for approval.

3.20 RECORD DRAWINGS:

A. The Contractor shall provide and maintain on the site an up-to-date record set of approved shop drawing prints which shall be marked to show each and every change made to the sprinkler system from the original approved shop drawings. This shall not be construed as authorization to deviate from or make changes to the shop drawings approved by the Owner without written instruction from the Owner in each case. This set of drawings shall be used only as a record set.

B. Upon completion of the work, the record set of prints shall be used to prepare complete, accurate final record drawings reflecting any and all changes and deviations made to the sprinkler system.

C. The Owner, at his option and at the Contractor's expense, may require revised hydraulic calculations depending on the extent and nature of field changes.

D. The Record Drawings and Hydraulic Calculations shall have the signed stamp of a professional engineer registered in the State of Colorado certifying the Record Drawings and the Hydraulic Calculations accurately represent the completed fire protection system.

E. Upon completion of the work, two sets of blueline record drawings shall be submitted to the Owner for review.
F. Upon review and approval, submit final drawings on computer disc to the University, in University of Colorado Standard CAD format.

3.21 GUARANTEE PERIOD:

A. Guarantee: The Contractor shall guarantee all materials and workmanship for a period of one year beginning with the date of final acceptance by the Owner. The Contractor shall be responsible during the design, installation, testing and guarantee periods for any damage caused by him (or his subcontractors) or by defects in his (or his subcontractors') work, materials, or equipment.

B. Emergency Service: During the installation and warranty period, the Contractor shall provide emergency repair service for the sprinkler system within four hours of a request by the Owner for such service. This service shall be provided on a 24 hour per day, seven days per week basis.

3.22 TRAINING:

A. The Contractor shall conduct two (2) training sessions of four (4) hours each to familiarize the building personnel with the features, operation and maintenance of the sprinkler systems. Training sessions shall be scheduled by the Owner at a time mutually agreeable to the Contractor and the Owner.

3.23 WATER DAMAGE:

A. The Fire Protection Contractor shall be responsible for any damage to the work of others, to building and property/materials of others caused by leaks in automatic sprinkler equipment, unplugged or disconnected pipes or fittings, and shall pay for necessary replacement or repair of work or items so damaged during the installation, testing or guarantee periods of the automatic sprinkler work.

END OF SECTION 21 10 00
SECTION 22 05 00
COMMON WORK RESULTS FOR PLUMBING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

A. All drawings associated with the entire project, including The General Conditions of the Contract for Construction, General and Supplementary Conditions and Division-1 Conditions specification sections shall apply to the Division 22 specifications and drawings. The Contractor shall be responsible for reviewing and becoming familiar with the aforementioned and all other Contract Documents associated with the project.

B. Related Sections: Refer to all sections in Division 22. Refer to Division 26 specification sections and Division 26 drawings.

C. Where contradictions occur between this section and Division 1, the more stringent requirement shall apply.

D. Contractor shall be defined as any and all entities involved with the construction of the project.

1.2 SUMMARY:

A. This Section specifies the basic requirements for mechanical installations and includes requirements common to more than one section of Division 22. It expands and supplements the requirements specified in Division 1.

1.3 MECHANICAL INSTALLATIONS:

A. The Contract Documents are diagrammatic, showing certain physical relationships which must be established within the mechanical work and its interface with all other work. Such establishment is the exclusive responsibility of the Contractor. Drawings shall not be scaled for the purpose of establishing material quantities.

B. Drawings and specifications are complementary. Whatever is called for in either is binding as though called for in both. Report any discrepancies to the Engineer and obtain written instructions before proceeding. Where any contradictions occur between the specifications and the drawings the more stringent requirement shall apply. The contractor shall include pricing for the more stringent and expensive requirements.

C. Drawings shall not be scaled for rough-in measurements or used as shop drawings. Where drawings are required for these purposes or have to be made from field measurement, Contractor shall take the necessary measurements and prepare the drawings.

D. The exact location for some items in this specification may not be shown on the drawings. The location of such items may be established by the Engineer during the progress of the work.

E. The contract documents indicate required size and points of terminations of pipes, and suggest proper routes to conform to structure, avoid obstructions and preserve clearances. It is not intended that drawings indicate necessary offsets. The contractor shall make the installation in such a manner as to conform to the structure, avoid obstructions, preserve headroom and keep openings and passageways clear, without further instructions or costs to the Owner. All equipment shall be installed so access is maintained for serviceability.
F. Before any work is installed, determine that equipment will properly fit the space; that required piping grades can be maintained and that ductwork can be run as intended without interferences between systems, structural elements or work of other trades.

G. Verify all dimensions by field measurements.

H. Coordinate installation in chases, slots and openings with all other building components to allow for proper mechanical installations.

I. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the work. Give particular attention to large equipment requiring positioning prior to closing-in the building.

J. Where mounting heights are not detailed or dimensioned, install mechanical services and overhead equipment to provide the maximum headroom possible.

K. Install mechanical equipment to facilitate maintenance and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.

L. Make allowance for expansion and contraction for all building components and piping systems that are subject to such.

M. The ceiling space shall not be “layered”. It is the contractor’s responsibility to offset any system as required to allow installation within the identified ceiling cavity. The contractor shall include labor and material in the base bid to accommodate such offsets.

N. In general, all “static” piping systems shall be routed as high as possible, i.e. fire protection systems. Keep all equipment in accessible areas such as corridors and coordinate with systems and equipment from other sections.

O. The Contractor shall provide all labor and material necessary but not limited to the starting/stopping of all mechanical equipment, opening/closing of all valves, draining/refilling all mechanical systems and operating/verifying the operation of all mechanical systems controls as required to accomplish all work necessary to meet construction document requirements. Contractor shall submit records of such activities to engineer and include in the O & M manuals.

P. All work shall operate in accordance with the Vibration, Siesmic and Sound Control specification under all conditions of load.

Q. Sound or vibration conditions not in accordance with the Vibration, Seismic and Sound Section and considered objectionable by the University shall be corrected in a manner approved by the project Architect under the work of Division 22/23.

1.4 COORDINATION:

A. Work out all installation conditions in advance of installation. The Contractor shall be responsible for preparing coordination drawings, showing all work, in all areas. The Contractor shall be responsible for providing all labor and material, including but not limited to all fittings, isolation valves, offsets, hangers, control devices, etc., necessary to overcome congested conditions at no increase in contact sum. The Contractors base bid shall include any and all time and manpower necessary to develop such coordination efforts and drawings. Increases to contract sum or schedule shall not be considered for such effort.
B. Provide proper documentation of equipment, product data and shop drawings to all entities involved in the project. Coordination shall include, but not be limited to the following:

1. Fire Protection and Fire Alarm Contractor shall provide shop drawings to all other Contractors.

2. Automatic Temperature Controls, Building Management and Testing, Adjusting and Balancing Contractors shall be provided with equipment product data and shop drawings from other Contractors and shall furnish the same information involving control devices to the appropriate Contractor.

C. Coordination Drawings:

1. Coordination drawings shall be prepared by the Contractor for his utilization and are his responsibility to assure systems will be installed in a manner to allow all systems to function properly.

2. Submit drawings for all areas, those places where clearances are limited, where space problems exist, for places where several elements of work (or combinations of mechanical and other work) must be located with precision in order to fit into available space, where sequencing is of importance to the efficient flow of work and as specified, and required.

3. Coordination drawings are informational submittals. Submit coordination drawings to Engineer for information only to document proper coordination of all portions of work and that coordination issues have been identified and resolved prior to submitting to the Engineer and prior to commencing construction in each affected area. The review of the coordination drawings by the Engineer does not constitute a relief of responsibility of the Contractor or a change to the contract documents. The Contractor shall have sole responsibility in developing a fully coordinated and integrated ceiling cavity.

4. The Contractor shall take the lead in coordinating and drawing Electrical and other Division 21, 22 & 23 components such as fire protection, plumbing, piping, sheet metal, etc. Where appropriate, the Contractor shall include medical gas, conduit, cable trays, pneumatic tube and any other system which may occupy the ceiling cavity.

5. Clearly indicate solutions to space problems. Identification of space problems without solutions is not acceptable. Only areas clearly identified will be reviewed.

6. All coordination drawings shall be 3D, with provision for collision check. The contractor is responsible for obtaining the architectural and structural files in 3D. All 3D drawing development, collision check, coordination, etc. shall be included as part of the Contractors base bid.

7. Prepare 3D Coordination Drawings (Shop Drawings) at a suitable scale, showing the required dimensions. In addition to the mentioned areas above, also submit the following:

   a. All mechanical equipment rooms such as fan rooms, boiler rooms, fire protection system rooms, etc. (1/4”=1’-0” scale).

   b. All building floor plans (1/8”=1’-0” scale). Include all shafts with clearances.

   c. Air handling unit, etc. main duct connections and transitions in ceiling space and to shafts or horizontal ducts. (1/4”=1’-0”).

   d. Required access for all equipment requiring code or maintenance access.
e. All sections and elevations necessary for clarification.

f. Indicate all seismic restraint and support systems to be used for all mechanical equipment throughout the project.

g. Indicate locations of ceiling and wall access panels and other necessary access space.

h. Indicate duct and pipe elevations. Indicate clearances for installing and maintaining insulation.

i. Indicate access to isolation valves.

j. Indicate clearances for servicing and maintaining equipment, valve stem movement, and similar requirements.

k. Indicate movement and positioning of large equipment into the building during construction. Indicate pipe and duct size. Indicate equipment tags.

8. CADD Drawings: Electronic mechanical AutoCAD drawings are available for purchase by the Contractor from the Engineer. Contact Engineer for further information in acquiring CADD drawings. The Engineers Construction documents cannot be used directly for coordination drawings. They are for information and initial coordination only.

D. Utility Connections:

1. Coordinate connection of mechanical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies and controlling agencies. Provide required connection for each service.

2. The contract documents indicate the available information on existing utilities and services and on new services (if any) to be provided to the project by utility companies and agencies. Notify Engineer immediately if discrepancies are found.

3. Coordinate mechanical utility interruptions one week in advance with the Owner and the Utility Company. Plan work so that duration of the interruption is kept to a minimum.

1.5 COORDINATION WITH OTHER DIVISIONS:

A. General:

1. Coordinate all work to conform with the progress of the work of other trades.

2. Complete the entire installation as soon as the condition of the building will permit. No extras will be allowed for corrections of ill timed work, when such corrections are required for proper installation of other work.

B. Coordinate ceiling cavity space carefully with all trades. In the event of conflict, install mechanical and electrical systems within the cavity space allocation in the following order of priority:

1. Equipment and required clearances
2. Plumbing waste, cooling coil drain piping and roof drain mains and leaders.
3. Ductwork mains
4. Plumbing vent piping
5. Med gas/lab gas systems
6. Low pressure ductwork and air devices.
7. Electrical and communication conduits, raceways and cabletray.
8. Domestic hot and cold water
9. Hydronic piping
10. Fire sprinkler mains, branch piping and drops (locate as tight to structure as possible).
11. DDC control wiring and other low voltage systems.
12. Fire alarm systems.

C. Chases, Inserts and Openings:

1. Provide measurements, drawings and layouts so that openings, inserts and chases in new construction can be built in as construction progresses.
2. Check sizes and locations of openings provided. Including the access panels for equipment in hard lid ceilings and wall cavities.
3. Any cutting and patching made necessary by failure to provide measurements, drawings and layouts at the proper time shall be done at no additional cost in contract sum.

D. Support Dimensions: Provide dimensions and drawings so that concrete basis and other equipment supports to be provided under other sections of the specifications can be built at the proper time.

E. Coordinate the installation of required supporting devices and sleeves to be set in poured in place concrete and other structural components, as they are constructed.

F. Coordinate the cutting and patching of building components to accommodate the installation of mechanical equipment and materials. Refer to Division 1, 22, 23.

G. Modifications required as result of failure to resolve interferences, provide correct coordination drawings or call attentions to changes required in other work as result of modifications shall be paid for by responsible Contractor/Subcontractor.

H. Coordination with Electrical Work: Refer to Division 1 and 26.

1.6 DESIGN WORK REQUIRED BY CONTRACTOR:

A. The construction of this project requires the Contractor to include the detailing and design of several systems and/or subsystems. All such design work associated with the development of the coordination drawings shall be the complete responsibility of the Contractor.

B. The Contractor shall take the full responsibility to develop and complete routing strategies which will allow fully coordinated system to be installed in a fully functional manner. The Engineers contract drawings shall be for system design intent and general configurations.

C. Systems or subsystems which require design responsibility by the contractor include but are not limited to:

1. Final coordinated distribution of duct, hydronic, plumbing and other systems within the ceiling cavity.
2. Any system not fully detailed
3. Fire protection systems
4. Equipment supports, hangers, anchors and seismic systems not fully detailed nor specified in these documents, or catalogued by the manufacturer.
5. Temperature controls systems
6. Refrigeration systems
D. Design Limitations:

1. The Contractor shall not modify the Engineer's design intent in any way.
2. The Contractor shall not change any duct size, pipe size or equipment size without prior written approval from the Engineer.
3. The Contractor shall conform to the SMACNA Duct Construction Standards when modifying the ductwork layout to avoid collisions.
4. Back to back 90° fittings on duct system shall not be installed under any circumstance.
5. Bull nosed tees on piping systems shall not be installed under any circumstance.

1.7 PROJECT CONDITIONS:

A. The Contractor shall be required to attend a mandatory pre-bid walk-thru and shall make themselves familiar with the existing conditions. No additional costs to the Owner shall be accepted for additional work for existing conditions.

B. Field verify all conditions prior to submitting bids.

C. Report any damaged equipment or systems to the Owner prior to any work.

D. Protect all mechanical and electrical work against theft, injury or damage from all causes until it has been tested and accepted.

E. Be responsible for all damage to the property of the Owner or to the work of other contractors during the construction and guarantee period. Repair or replace any part of the work which may show defect during one year from the final acceptance of all work, provided such defect is, in the opinion of the Architect, due to imperfect material or workmanship and not due to the Owner’s carelessness or improper use.

F. The Contractor shall coordinate and co-operate with Owner at all times for all new to existing connections, system shutdowns and start-ups, flushing and filling both new and existing systems.

G. Provide temporary ductwork and piping services, where required, to maintain existing areas operable.

H. Coordinate all services shut-down with the Owner; provide temporary services. Coordinate any required disruptions with Owner, one week in advance.

I. Minimize disruptions to operation of mechanical systems in occupied areas.

1.8 SAFETY:

A. Refer to Division 1.

1.9 EQUAL EMPLOYMENT OPPORTUNITY REQUIREMENTS:

A. Refer to Division 1 and conform with the Owners requirements.

1.10 REQUIREMENTS OF REGULATORY AGENCIES:

A. Refer to Division 1.

B. Execute and inspect all work in accordance with all Underwriters, local and state codes, 2009 UCB Standards, rules and regulations applicable to the trade affected as a minimum, but if the plans and/or specifications call for requirements that exceed these rules and regulations, the greater requirement shall be followed. Follow recommendations of NFPA, SMACNA, EPA, OSHA and ASHRAE.
C. Comply with standards in effect at the date of these Contract Documents, except where a standard or specific date or edition is indicated.

D. The handling, removal and disposal of regulated refrigerants shall be in accordance with U.S. EPA, state and local regulations.

E. The handling, removal and disposal of lead based paint and other lead containing materials shall comply with EPA, OSHA, and any other Federal, State, or local regulations.

F. After entering into contract, Contractor will be held to complete all work necessary to meet these requirements without additional expense to the Owner.

1.11 REQUIREMENTS OF LOCAL UTILITY COMPANIES:

A. Comply with rules and regulations of local utility companies. Include in bid the cost of all valves, valve boxes, meter boxes, meters and such accessory equipment which will be required but not provided by Local Utility Company for the project.

1.12 PERMITS AND FEES:

A. Refer to Division 1.

B. The Contractor shall pay all tap, development, meter, etc., fees required for connection to municipal and public utility facilities, unless directed otherwise by the General Contractor/Owner – IN WRITING.

C. Contractor shall arrange for and pay for all inspections, licenses and certificates required in connection with the work.

1.13 TEMPORARY FACILITIES:

A. Light, Heat, Power, Etc.: Responsibility for providing temporary electricity, heat and other facilities shall be as specified in Division 1.

1.14 PRODUCT OPTIONS AND SUBSTITUTIONS:

A. Refer to the Instructions to Bidders and Division 1.

1.15 MECHANICAL SUBMITTALS:

A. General

1. Refer to the Conditions of the Contract (General and Supplementary), Division 1.

2. The submittals shall be submitted as one package identified by the specification section. Submittals that are not complete with the required information will be sent back to be corrected.

3. The Contractor shall identify any "long lead time" items which may impact the overall project schedule. If these submittal requirements affect the schedule, the Contractor shall identify the impacts and confer with the Engineer within two weeks of entering into the contract.

4. The submittal package shall be provided in electronic format. The cover shall be identified with the job name, Owner's project number, date, Prime Contractor's name, etc.

5. An index shall be provided which includes:
   a. Product
b. Plan Code (if applicable)
c. Specification Section
d. Manufacturer and Model Number

6. All mechanical divisions shall be submitted at one time. Long lead items may be submitted prior to full submittal if necessary and only with prior approval.

7. Fire protection and coordination drawings do not apply to the above. These drawings may be submitted in a separate submittal.

B. The manufacturer's material or equipment listed in the schedule or identified by name on the drawings are the types to be provided for the establishment of size, capacity, grade and quality. If alternates are used in lieu of the scheduled names, the cost of any changes in construction required by their use shall be borne by Contractor.

C. All equipment shall conform to the State and/or local Energy Conservation Standards and UCB requirements.

D. Submittal of shop drawings, product data and samples will be accepted only when submitted by and stamped by the General Contractor. Data submitted from Subcontractors and material suppliers directly to the Engineer will not be processed unless prior written approval is obtained by the General Contractor.

E. Before starting work, prepare and submit to the Architect/Engineer all shop drawings and descriptive equipment data required for the project. Unless each item is identified with the specification section and sufficient data to identify its compliance with the specifications and drawings, the item will be returned "Revise and Resubmit". Where an entire submittal package is returned for action by the Contractor, the Engineer will summarize comments in letter format and return the entire set. Continue to submit any individual shop drawings, product data or samples which were returned without a "make corrections noted" or "no exceptions taken" action, until they are so marked. When a "Make Corrections Noted" is received, make the required corrections for inclusion in the operation and maintenance manual. Submittals marked "Make Corrections Noted" shall not be resubmitted during the submittal process.

F. The Design Professional’s review and appropriate action on all submittals and shop drawings is only for the limited purpose of checking for conformance with the design concept and the information expressed in the contract documents. This review shall not include:

1. Accuracy or completeness of details, such as quantities, dimensions, weights or gauges, fabrication processes
2. Construction means or methods
3. Coordination of the work with other trades
4. Construction safety precautions

G. The Design Professional’s review shall be conducted with reasonable promptness while allowing sufficient time in the Design Professional’s judgment to permit adequate review. Review of a specific item shall not indicate that the Design Professional has reviewed the entire assembly of which the item is a component.

H. The Design Professional shall not be responsible for any deviations from the contract documents not brought specifically to the attention of the Design Professional in writing by the Contractor. This shall clearly identify the design and the specific element which vary from the Design. The Contractor shall be responsible for all remedy for lack of strict conformance associated with this criteria.

I. The Design Professional shall not be required to review partial submissions or those for which submissions of correlated items have not been received.
1.16 SPECIFIC CATEGORY SUBMITTAL REQUIREMENTS:

A. Product Data:

1. Where pre-printed data covers more than one distinct product, size, type, material, trim, accessory group or other variation, mark submitted copy with black pen to indicate which of the variations is to be provided.

2. Delete or mark-out portions of pre-printed data which are not applicable.

3. Where operating ranges are shown, mark data to show portion of range required for project application.

4. For each product, include the following:
   a. Sizes.
   b. Weights.
   c. Speeds.
   d. Capacities.
   e. Piping and electrical connection sizes and locations.
   f. Statements of compliance with the required standards and regulations.
   g. Performance data.
   h. Manufacturer's specifications.

B. Shop Drawings:

1. Shop Drawings are defined as mechanical system layout drawings prepared specifically for this project, or fabrication and assembly type drawings of system components to show more detail than typical pre-printed materials.

2. Prepare Mechanical Shop Drawings, except diagrams, to accurate scale, min 1/8”-1'-0”, unless otherwise noted.
   a. Show clearance dimensions at critical locations.
   b. Show dimensions of spaces required for operation and maintenance.
   c. Show interfaces with other work, including structural support.

3. Provide plumbing isometrics with locations of isolation valves shown.

C. Test Reports:

1. Submit test reports which have been signed and dated by the accredited firm or testing agency performing the test.

2. Prepare test reports in the manner specified in the standard or regulation governing the test procedure (if any) as indicated.

3. Submit test reports as required for O & M manuals.

D. Product Listing:

1. Prepare listing of major mechanical equipment and materials for the project, within (2) two weeks of signing the Contract Documents and transmit to the Architect. A sample schedule is included at the end of this section to complete this requirement.
   a. Provide all information requested.
   b. Submit this listing as a part of the submittal requirement specified in Division 1, "PRODUCTS AND SUBSTITUTION."
2. Unless otherwise specified, all materials and equipment shall be of domestic (USA) manufacture and shall be of the best quality used for the purpose in commercial practice.

3. When two or more items of same material or equipment are required (plumbing fixtures, pumps, valves, air conditioning units, etc.) they shall be of the same manufacturer. Product manufacturer uniformity does not apply to raw materials, bulk materials, pipe, tube, fittings (except flanged and grooved types), sheet metal, wire, steel bar stock, welding rods, solder, fasteners, motors for dissimilar equipment units and similar items used in work, except as otherwise indicated.

   a. Provide products which are compatible within systems and other connected items.

E. Schedule of Values

1. Provide preliminary schedule of values with product data submittal, within three (3) weeks from award of contract to successful bidder. Provide according to the following descriptions:

   a. Site Utilities
   b. Plumbing
   c. Insulation

2. Provide a final Schedule of Values at close-out of project including updated values based on actual installation.

F. Coordination Drawings: See section 1.4 of this specification section.

G. Required Submittals: Provide submittals for each item of equipment specified or scheduled in the contract documents. See table at the end of this section.

H. If more than two submittals (either for product data, shop drawings, record drawings, or test and balance reports) are made by the Contractor, the Owner reserves the right to charge the Contractor for subsequent reviews by their consultants. Such extra fees shall be deducted from payments by the Owner to the Contractor.

1.17 DELIVERY, STORAGE, AND HANDLING:

A. Refer to Division 1.

B. Deliver products to project properly identified with names, model numbers, types, grades, compliance labels and similar information needed for distinct identifications; adequately packaged and protected to prevent damage or contamination during shipment, storage, and handling.

C. Check delivered equipment against contract documents and submittals.

D. Store equipment and materials at the site, unless off-site storage is authorized in writing. Protect stored equipment and materials from damage, dirt, dust, freezing, heat and moisture.

E. Coordinate deliveries of mechanical materials and equipment to minimize construction site congestion. Limit each shipment of materials and equipment to the items and quantities needed for the smooth and efficient flow of installations.

F. Provide factory-applied plastic end-caps on each length of pipe and tube, except for concrete, corrugated metal, hub-and-spigot, clay pipe. Maintain end-caps through shipping, storage and handling to prevent pipe-end damage and prevent entrance of dirt, debris and moisture.
G. Protect stored ductwork, pipes and tubes. Elevate above grade and enclose with durable, waterproof wrapping. When stored inside, do not exceed structural capacity of the floor.

H. Protect flanges, fittings and specialties from moisture and dirt by inside storage and enclosure, or be packaging with durable, waterproof wrapping.

I. Protect sheet metal ductwork and fittings. Elevate and store above grade and cover ends with waterproof wrapping.

1.18 CUTTING AND PATCHING:

A. This Article specifies the cutting and patching of mechanical equipment, components and materials to include removal and legal disposal of selected materials, components and equipment.

B. Refer to Division 1.

C. Do not endanger or damage installed work through procedures and processes of cutting and patching.

D. Arrange for repairs required to restore other work, because of damage caused as a result of mechanical installations.

E. No additional compensation will be authorized for cutting and patching work that is necessitated by ill-timed, defective or non-conforming installations.

F. Perform cutting, fitting and patching of mechanical equipment and materials required to:

1. Uncover work to provide for installation of ill-timed work;
2. Remove and replace defective work;
3. Remove and replace work not conforming to requirements of the Contract Documents;
4. Remove samples of installed work as specified for testing;
5. Install equipment and materials in existing structures;
6. Upon written instructions from the Architect/Engineer, uncover and restore work to provide for Architect/Engineer observation of concealed work.

G. Construction and pre-occupancy indoor air quality (AQ) management:

1. During construction, meet or exceed the recommended design approaches of the SMACNA 1 AQ guideline for occupied buildings under construction, 1995, Chapter 3.

1.19 ROUGH-IN:

A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

B. Refer to equipment shop drawings and manufacturer's requirements for actual provided equipment for rough-in requirements.

C. Work through all coordination before rough-in begins.

1.20 ACCESSIBILITY:

A. Install equipment and materials to provide required access for servicing and maintenance. Coordinate the final location of concealed equipment and devices requiring access with final location of required access panels and doors. Allow 36” clearance for removal of all parts that require replacement or servicing.
B. Extend all grease fittings to an accessible location.

C. Furnish hinged steel access doors with concealed latch, whether shown on drawings or not, in all walls and ceilings for access to all concealed valves, shock absorbers, air vents, motors, dampers, equipment controls, fans, balancing cocks, and other operating devices requiring adjustment or servicing. Refer to Division 1 for access door specification and Division 22 for duct access door requirements.

D. The minimum size of any access door shall not be less than the size of the equipment to be removed or 24 inches x 24 inches if used for service only.

E. Furnish doors to trades performing work in which they are to be built, in ample time for building-in as the work progresses. Whenever possible, group valves, cocks, etc., to permit use of minimum number of access doors within a given room or space.

F. Factory manufactured doors shall be of a type compatible with the finish in which they are to be installed. In lieu of these doors, approved shop fabricated access doors with DuroDyne hinges may be used.

G. Access doors in fire-rated walls and ceilings shall have equivalent U.L. label and fire rating.

1.21 BELTS, SHEAVES, IMPELLERS:

A. The Mechanical Contractor shall coordinate with the Test and Balance Contractor and supply correctly-sized drive belts, sheaves, and trimmed impellers.

1.22 EXCAVATING AND BACKFILLING:

A. General:

1. Provide all necessary excavation and backfill for installation of mechanical work in accordance with Division 2.

B. Contact Owners of all underground utilities to have them located and marked, at least 2 business days before excavation is to begin. Also, prior to starting excavation brief employees on marking and color codes and train employees on excavation and safety procedures for natural gas lines. When excavation approaches gas lines, expose lines by carefully probing and hand digging.

C. Provide all necessary pumping, cribbing and shoring.

D. Walls of all trenches shall be a minimum of 6 inches clearance from the side of the nearest mechanical work. Install pipes with a minimum of 6 inches clearance between them when located in same trench.

E. Pipe Trenching:

1. Dig trenches to depth, width, configuration, and grade appropriate to the piping being installed. Dig trenches to 6 inches below the level of the bottom of the pipe to be installed. Install 6 inches bed of pea gravel or squeegee, mechanically tamp to provide a firm bed for piping, true to line and grade without irregularity. Provide depressions only at hubs, couplings, flanges, or other normal pipe protrusions.

F. Backfilling shall not be started until all work has been inspected, tested and accepted. All backfill material shall be reviewed by the soils engineer. In no case shall lumber, metal or other debris be buried in with backfill.
1. Provide warning tape for marking and locating underground utilities. Tape shall be specifically manufactured for this purpose and shall be polyethylene film, 6 inches wide, 0.004 inches thick and have a minimum strength of 1750 psi. Tape shall carry continuous inscription naming the specific utility.
   
a. Tape shall have magnetic strip and be used for exterior underground system only.

G. Trench Backfill:
   
1. Backfill to 12 inches above top of piping with pea gravel or squeegee, the same as used for piping bed, compact properly.

2. Continue backfill to finish grade, using friable material free of rock and other debris. Install in 6 inch layers, each properly moistened and mechanically compacted prior to installation of ensuing layer. Compaction by hydraulic jetting is not permissible.

H. After backfilling and compacting, any settling shall be refilled, tamped, and refinished at this contractor's expense.

I. This contractor shall repair and pay for any damage to finished surfaces.

J. Complete the backfilling near manholes using pea gravel or squeegee, installing it in 6 inch lifts and mechanically tamping to achieve 95 percent compaction.

K. Use suitable excavated material to complete the backfill, installed in 6 inch lifts and mechanically compacted to seal against water infiltration. Compact to 95 percent for the upper 30 inches below paving and slabs and 90 percent elsewhere.

1.23 NAMEPLATE DATA:

A. Provide permanent operational data nameplate, on each item of mechanical equipment, indicating manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliances, and similar essential data. Locate nameplates in an accessible location. Coordinate with Owner for specific requirements.

B. Campus Famis labels will be provided by UCB for contractor to install.

1.24 LUBRICATION OF EQUIPMENT:

A. Refer to Division 1. The following paragraphs supplement the requirements of Division 1.

B. Contractor shall properly lubricate all mechanical pieces of equipment which he provided before turning the building over to the Owner. He shall attach a linen tag or heavy duty shipping tag on the piece of equipment showing the date of lubrication and the type and brand of lubricant used.

C. Furnish the Engineer with a typewritten list included in the O and M manuals of each item lubricated and type of lubricant used, no later than two (2) weeks before completion of the project, or at time of acceptance by the Owner of a portion of the building and the mechanical systems involved.

1.25 CLEANING:

A. Refer to Division 1.

B. Refer to Division 22, "TESTING, ADJUSTING AND BALANCING" for requirements for cleaning filters, strainers, and mechanical systems prior to final acceptance.
1.26 RECORD DOCUMENTS:

A. Refer to Division 1. The following paragraphs supplement the requirements of Division 1.

B. Keep a complete set of record document prints in custody during entire period of construction at the construction site. Documents shall be updated on a weekly basis.

C. Mark Drawing Prints to indicate revisions to piping and ductwork, size and location both exterior and interior; including locations of coils, dampers and other control devices, filters, boxes, and similar units requiring periodic maintenance or repair; actual equipment locations, dimensioned from column lines; actual inverts and locations of underground piping; concealed equipment, dimensioned to column lines; mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located (i.e., traps, strainers, expansion compensators, tanks, etc.); Change Orders; concealed control system devices. Changes to be noted on the drawings shall include final location of any piping or ductwork relocated more than 1 foot-0 inches from where shown on the drawings.

D. At the completion of the project, obtain from the Architect a complete set of the Mechanical Construction Documents in the electronic format used by the design team. This set will include all revisions officially issued through the Architect. The Contractor shall transfer all revisions noted on the record document prints to the electronic drawings. The Contractor shall transmit the final record documents in the electronic format used on the project to the Architect. This contract will not be considered completed until these record drawings have been received and reviewed by the Architect/Engineer.

1.27 OPERATION AND MAINTENANCE DATA:

A. Refer to Division 1.

B. The testing and balancing report shall be submitted and received by the Engineer at least fifteen calendar days prior to the contractor's request for final observation time frame requirements. Include in the O & M Manual after review with "No Exceptions Taken" has been accomplished.

C. In addition to the information required by Division 1 for Maintenance Data, include the following information:

1. Description of mechanical equipment, function, installation instructions, drawing specification, complete wiring and temperature controls diagrams, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of all replaceable parts.

2. Manufacturer's printed operating procedures to include start-up, break-in, routine and normal operating instructions; regulation, control, stopping, shut-down, and emergency instructions; and summer and winter operating instructions. Provide any test reports and start-up documents.

3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.

4. Servicing instructions, lubrication charts and schedules, including Contractor lubrication reports.

5. Manufacturer's service manuals for all mechanical equipment provide under this contract.

6. Include the valve tag list.
7. Alphabetical list of all system components including the name, address and 24 hour phone number of the company responsible for servicing each item during the 1st year's operation.

8. Starting, stopping, lubrication, equipment identification numbers and adjustment clearly indicated for each piece of equipment.

9. Complete parts list. Provide to Owner, recommended spare parts list.

10. Mechanical warranties.

11. Final schedule of values with all mechanical change order costs included and identified.


13. Appropriate start-up information by factory representative.

14. On-site dynamic balancing report by independent balancing firms of all Labs.

D. This contract will not be considered completed nor will final payment be made until all specified material, including testing and balancing report and final schedule of values with all mechanical change order costs included and identified, is received in this operating and maintenance report and the manual is reviewed by the Architect.

1.28 PROJECT CLOSEOUT:

A. In addition to the requirements specified in Division 1, complete the requirements listed below.

B. The Contractor shall be responsible for the following Mechanical Checklist either by performing and/or coordinating such items prior to applying for certification of substantial completion. Refer to individual specification sections for additional requirements.

C. Contractor shall be responsible for scheduling instructional meetings for maintenance personnel on the proper operation and maintenance of all mechanical systems, using the “Operation and Maintenance Manual” as a guide.
1.29 **WARRANTIES:**

A. Refer to the Division 1 for procedures and submittal requirements for warranties. Refer to individual equipment specifications for warranty requirements. In any case the entire mechanical system shall be warranted no less than one year from the time of acceptance by the Owner.

B. Compile and assemble the warranties specified in Division 21, 22 & 23, into the operating and maintenance manuals.

C. Provide complete warranty information for each item to include product or equipment to include date or beginning of warranty or bond; duration of warranty or bond; and names, addresses, and telephone numbers and procedures for filing a claim and obtaining warranty services.

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1. For Soft Starters and Variable Frequency Drives
2. Requires Review & Approval from T & B Contractor
3. Warranty Report/Warranty
4. Kitchen Exhaust Hood
5. See Specific Specification Section for Test & Certification Requirements

END OF SECTION 22 05 00
SECTION 22 05 13
MECHANICAL/ELECTRICAL REQUIREMENTS FOR PLUMBING EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. This section specifies the basic requirements for electrical components which are either separate components or are an integral part of all mechanical equipment. These components include, but are not limited to factory installed motors, starters, variable frequency drives and disconnect switches furnished as an integral part of packaged mechanical equipment.

B. Wiring of field-mounted switches and similar mechanical-electrical devices provided for mechanical systems, to equipment control panels.

C. Specific electrical requirements (i.e. horsepower and electrical characteristics) for mechanical equipment are scheduled on the Electrical Drawings. In case of conflict, Electrical Drawings shall take precedence. Do not purchase motors or electrical equipment until power characteristics available at building site location have been confirmed by Contractor.

D. Refer to Table in the Electrical Division for Mechanical/Electrical coordination.

1.2 QUALITY ASSURANCE:

A. Manufacturers: Firms regularly engaged in manufacture of motors, motor starters and drives of types, ratings and characteristics required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Single Manufacturer: Provide all motors and starters for the project by a single manufacturer except when part of factory packaged equipment. All variable frequency drives and soft start starters for the project shall be by a single manufacturer, including packaged equipment except chillers.

C. Installer's Qualifications: Firm with at least 3 years of successful installation experience on projects utilizing motors, motor starters, capacitors and drives similar to that required for this project.

D. NEC Compliance: Comply with NEC as applicable to wiring methods, construction and installation of motors, motor starters, capacitors and drives.

E. NFPA Compliance: Comply with applicable requirements of NFPA 70E, "Standard for Electrical Safety Requirements for Employee Workplaces”.

F. UL Compliance: Comply with applicable requirements of UL 486A, "Wire Connectors and Soldering Lugs for Use with Copper Conductors", and UL 508, "Electrical Industrial Control Equipment" pertaining to installation of motor starters.

G. UL Compliance: Provide equipment and components which are UL-listed and labeled.

H. ETL Compliance: Provide equipment and components which are ETL-listed and labeled.


K. Standards:

1. NEMA Standards MG 1: Motors and Generators.
2. NEMA Standard ICS 2: Industrial Control Devices, Controllers, and Assemblies.
5. Comply with National Electrical Code (NFPA 70).

L. Coordination with Electrical Work: Wherever possible, match elements of electrical provisions of mechanical work with similar elements of electrical work specified in Division 26 sections. Comply with applicable requirements of Division 26 sections for electrical work of this section which are not otherwise specified.

1.3 SUBMITTALS:

A. Product Data: Submit in accordance with Section 22 05 00.

B. Shop Drawings: Submit dimensional drawings of VFD’s showing accurately scaled equipment layouts. Drawings shall include, as a minimum: physical dimensions of each unit; general arrangements with incoming and outgoing conduit locations, schematic; connection diagram sufficient to install system, and enclosure details.

C. Listing, Motors of Mechanical Work: Concurrently, with submittal of mechanical products listing, submit separate listing showing rating, power characteristics, efficiencies, power factors, application and general location of every motor to be provided with mechanical work. Submit updated information promptly when and if initial data is revised.

1. Include in listing of motors, notations of whether motor starter is furnished or installed integrally with motor or equipment containing motor.

D. Electrical coordination listing. Provide the following information for each field wired electrical power connection. Information shall use nameplate data and nomenclature of actual installed nameplates. Information should list as a minimum:

1. Field connection details such as maximum/minimum wire size lugs can accommodate. Include number of lugs per phase.
2. Number and location of field connections.
3. Field interconnection wiring.
4. Operating voltage and phase.
5. Maximum fuse size or maximum overcurrent protection size (as applies).
7. Full load amperes.
8. Locked rotor current and duration for high inertia equipment.
9. Manufacturers recommended overload setting (if applicable).

The contractor shall fully coordinate these items with all subcontractors prior to submittal.

1.4 PRODUCT STORAGE:

A. All motors not designed for exposure to water or moisture shall be protected at all times.
PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Subject to compliance with requirements, provide products by one of the following manufacturers for each type of product:

1. Motors
   a. AO Smith
   b. Baldor
   c. Reliance
   d. Westinghouse
   e. Toshiba
   f. Gould
   g. General Electric
   h. Louis Allis
   i. Lincoln
   j. ABB

2. Starters:
   a. Cutler Hammer
   b. Allen-Bradley
   c. Sprecher & Schuh (NEMA rated only)
   d. Square D
   e. General Electric
   f. Westinghouse
   g. Siemens

2.2 MOTORS:

A. The following are basic requirements for simple or common motors. For special motors, more detailed and specific requirements are specified in the individual equipment specifications.

1. Torque characteristics shall be sufficient to satisfactorily accelerate the driven loads with a time limit acceptable to the motor manufacturer. Motors shall be capable of starting the driven equipment while operating at 90 percent rated terminal voltage.

2. Motor sizes shall be large enough so that the driven load will not require the motor to operate in the service factor range.

3. 2-speed motors shall have (1) single winding on poly-phase motors.


5. Temperature Rating: Rated for 40 degrees C environment with maximum 80 degrees C temperature rise for continuous duty at full load (Class B Insulation). Provide Class F insulation for variable frequency drive motors.

6. Starting capability: Frequency of starts as indicated by automatic control system, and not less than 5 evenly time spaced starts per hour for manually controlled motors.
7. Service Factor: 1.15 for poly-phase motors, 1.35 for single phase motors, and 1.0 for inverter duty motors.

8. Altitude Deration: Motors must be selected to operate within nameplate horsepower at 5400 ft. elevation.

9. All motors rated greater than 1000W shall have a power factor of not less than 85% under rated load condition.

10. Motor construction: NEMA Standard MG 1, general purpose, continuous duty, Design "B", with Class F insulation.
   a. Frames: NEMA Standard No. 48 or 54; Use driven equipment manufacturer's standards to suit specific application.
   b. Bearings:
      1) Ball bearings with inner and outer shaft seals.
      2) Re-greasable, except permanently sealed where motor is normally inaccessible for regular maintenance.
      3) Bearings shall be rated for minimum L-10 life of 40,000 hours.
      4) Designed to resist thrust loading where belt drives or other drives produce lateral or axial thrust in motor.
      5) For fractional horsepower, light duty motors, sleeve type bearings are permitted.
   c. Enclosure Type:
      1) Open drip-proof motors for indoor use where satisfactorily housed or remotely located during operation.
      2) Guarded drip-proof motors where exposed to contact by employees or building occupants.
      3) Weather protected Type I for housed outdoor use, TEPC II where not housed.
   d. Overload protection: Built-in thermal overload protection for all single phase motors and, where indicated, internal sensing device suitable for signaling and stopping motor at starter.
   e. Noise rating: "Quiet". Motors shall not exceed 80DB rating when running at their full speed and power range.
   f. Motors 1hp and higher are to be premium efficient, complying with Xcel Energy requirements.
   g. All belt-drive motors over 5hp shall have dual push-pull adjustment screws for the motor mounts. For retrofits, the motor mounts must be replaced if not of this type.
   h. Nameplate: indicate the full identification of manufacturer, ratings, characteristics, construction, special features and similar information.
11. **Phases and Current Characteristics:** All motors shall be premium efficiency, unless indicated otherwise, provide squirrel-cage induction polyphase motors for 3/4 hp and larger, and provide capacitor-start single-phase motors for 1/2 hp and smaller, except 1/6 hp and smaller may, at equipment manufacturer's option, be split-phase type. Tri-voltage motors are not acceptable. Coordinate current characteristics with power specified in Division 26 sections. Do not purchase motors until power characteristics available at building site have been confirmed by contractor.

12. **The Contractor shall be responsible for all additional electrical and other costs involved to accommodate any motors which differ from the scheduled horsepower sizes or correct any motor which does not meet the listed efficiency as called for in mechanical or electrical plans and specifications.**

13. **Motors shall be of the same manufacturer, except those that are an integral part of a factory assembled packaged unit. These motors shall likewise meet the conditions of the specification in this section except motors which are part of a motor/compressor assembly are exempted from this requirement.**

### 2.3 STARTERS, ELECTRICAL DEVICES AND WIRING:

**A. Motor Starter Characteristics:**

1. Coordinate with the Electrical Contractor for motor control center starters provided by Division 26.
2. Enclosures: NEMA 1, general purpose enclosures with padlock ears, except in wet locations shall be NEMA 3R with conduit hubs, or units in hazardous locations which shall have NEC proper class and division.
3. Type and size of starter shall be as recommended by motor manufacturer and the driven equipment manufacturer for applicable protection and start-up condition.
4. Provide two-speed starters with a High-Low selector switch wired to allow manual speed selection with the H-O-A in HAND or remote speed selection in AUTO. Provide an automatic accelerating relay/timer to assure that the motor will always start at low speed and operate at an adjustable time before switching to high speed. Also, provide an integral automatic decelerating timing relay to prevent damage to the motor and load when switching from high to low speed. High and low speed contactors shall be mechanically and electrically interlocked. Complete instructions shall be provided for adjusting the timer in the field to match the deceleration characteristics of the driven equipment.
5. Contacts shall open each ungrounded connection to the motor. Contacts shall be NEMA style, sized and rated, 75 degrees C.

**B. Manual switches shall have:**

1. Maintained contacted push buttons with pilot lights for single-speed or multi-speed operation.
2. Overload protection: melting alloy type thermal overload relays.

**C. Magnetic Starters:**

1. Unless otherwise indicated, provide NEMA style, sized and rated magnetic starters including contacts and coils for motors 1/2 hp and larger and for smaller motors where interlock or automatic operation is indicated or required:
   a. Maintained contact H-O-A push buttons and pilot lights, properly arranged for single speed or multi-speed operation as indicated.
   b. Solid state adjustable motor overload. Select range so that upper limit is no more than 150 percent of the connected motor full load amps.
c. Interlocks, pneumatic switches and similar devices as required for coordination with control requirements of Division-15 Controls sections. In addition to the interlock & switches specified above each starter shall be provided with (4) four additional spare sets of auxiliary contacts, (2) two normally open & (2) two normally closed.
d. Built-in 120 volts control circuit transformer, fused from line side, where service exceeds 240 volts.
e. Under-voltage release or protection. Re-start of equipment shall be automatic.
f. All 3-phase motors 2 hp and larger shall be protected against loss of phase (single phasing protection) wired into the starter. Externally operated manual reset.
g. Where reduced voltage starting is required, the starting method shall be part winding or closed transition auto-transformer/solid state electronic starting. Motors shall be constructed accordingly. Other methods of reduced voltage starting shall not be used unless reviewed by the Engineer prior to bid.

D. Motor connections:
   1. Flexible conduit, except where plug-in electrical cords are specifically indicated.

2.4 DISCONNECT SWITCHES:
   A. See Division 26 for requirements.

2.5 EQUIPMENT FABRICATION:
   A. General: Fabricate mechanical equipment for secure mounting of motors and other electrical items included in work. Provide either permanent alignment of motors with equipment, or adjustable mountings as applicable for belt drives, special couplings and similar indirect coupling of equipment. Provide safe, secure, durable, and removable guards for motor drives, arranged for lubrication and similar running-maintenance without removal of guards.

PART 3 - EXECUTION

3.1 TEST AND TEST DATA:
   A. A factory load test shall be performed on each motor of 1000 watt input or greater to assure compliance with the energy-efficiency section of this specification.

   B. Typical test data on every motor to be used on this project shall be made available upon request.

3.2 INSTALLATION:
   A. Install motors on motor mounting systems in accordance with motor manufacturer's instructions, securely anchored to resist torque, drive thrusts, and other external forces inherent in mechanical work. Secure sheaves and other drive units to motor shafts with keys and Allen set screws, except motors of 1/3 hp and less may be secured with Allen set screws on flat surface of shaft. Unless otherwise indicated, set motor shafts parallel with machine shafts.

   B. Deliver starters and wiring devices which have not been factory-installed on equipment unit to electrical installer for installation.

   C. Install power and control connections for motors to comply with NEC and applicable provisions of Division 26 sections. Install grounding except where non-grounded isolation of motor is indicated.
3.3 INSTALLATION COORDINATION:

A. Furnish equipment requiring electrical connections to operate properly and to deliver full capacity at electrical service available.

B. Verify windings of multi-speed or reduced voltage starters are compatible with the connected motor prior to installation.

C. All control wiring to be in accordance with manufacturer's recommendations; all wiring shall be color coded to facilitate checking.

D. It is the intent of this specification that one "General" Contractor enters an agreement with the Owner. The use and coordination of subcontractors is at the option of the General Contractor. All mechanical equipment, motors and controls shall be furnished, set in place, and wired. The schedule contained in the Electrical Division is provided as a guide only. The exact furnishing and installation of the equipment is left to the Contractors involved. Contractor should note that the intent of the schedule is to have the Division 22 and 26 Contractors responsible for coordinating all control wiring as outlined, whether or not specifically called for by the mechanical or electrical drawings and specifications. Comply with the applicable requirements of Division 26 for all electrical work which is not otherwise specified. No extras will be allowed for Contractor's failure to provide for these required items. The Contractor shall refer to the Division 26 and Division 22 specifications and plans for all power and control wiring and shall advise the Architect/Engineer of any discrepancies prior to bidding.

END OF SECTION 22 05 13
PART 1 GENERAL

1.1 DESCRIPTION OF WORK:

A. Extent of meters and gauges required by this section is indicated on drawings and/or specified in other Division-22 sections.

B. Types of meters and gauges specified in this section include the following:

1. Temperature Gauges and Fittings:
   a. Dial Type Insertion Thermometers.
   b. Thermometer Wells.
   c. Temperature Gauge Connector Plugs.

2. Pressure Gauges and Fittings:
   a. Pressure Gauges.
   b. Pressure Gauge Cocks.
   c. Pressure Gauge Connector Plugs.

3. Flow Measuring Meters:
   b. Portable Flow Meter Read-out Kits.
   c. Flow Meters

C. Meters and gauges furnished as part of factory-fabricated equipment, are specified as part of equipment assembly in other Division-22 sections.

D. Provide gauges with dual units (standard and SI)

1.2 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacturer of meters and gauges, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Codes and Standards:

1. UL Compliance: Comply with applicable UL standards pertaining to meters and gauges.

2. ANSI and ISA Compliance: Comply with applicable portions of ANSI and Instrument Society of America (ISA) standards pertaining to construction and installation of meters and gauges.

C. Certification: Provide meters and gauges whose accuracies, under specified operating conditions, are certified by manufacturer.
1.3 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data, including installation instructions for each type of meter and gauge. Include scale range, ratings, and calibrated performance curves, certified where indicated. Submit meter and gauge schedule showing manufacturer's figure number, scale range, location, and accessories for each meter and gauge.

B. All flow measuring devices to be provided shall be reviewed and approved by the test & balance contractor and the temperature control contractor for proper scale, rangeability and function prior to submitting shop drawings. The test & balance contractor and temperature control contractor shall provide a typed letter stating this review has been completed and included with shop drawing submittals.

C. Maintenance Data: Submit maintenance data and spare parts lists for each type of meter and gauge. Include this data and product data in Maintenance Manual; in accordance with requirements of Division 22.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Manufacturer: Subject to compliance with requirements, provide products by one of the following:

1. Remote Reading Dial Thermometers:
   a. Miljoco
   b. Weiss Instruments, Inc.
   c. Pre-approved equal

2. Dial Type Insertion Thermometers and Wells:
   a. Marsh Instrument Co.; Unit of General Signal. – with UCB approval
   b. Taylor Instrument Co. – with UCB approval
   c. Trerice (H.O.) Co. – with UCB approval
   d. Weiss Instruments, Inc.

3. Photo Voltaic Digital Thermometers:
   a. Miljoco
   b. Weiss Instruments

4. Temperature Gauge Connector Plugs:
   a. Fairfax Company
   b. Peterson Equipment Co.
   c. Trerice

5. Pressure Gauges:
   b. Crosby
   c. Dwyer
d. Weksler

6. Pressure Gauge Connector Plugs:
   a. Fairfax Company
   b. Peterson Equipment Co.
   c. Trerice

7. Flow Indicator Switches:
   a. McDonnell and Miller
   b. Mueller
   c. Nexus
   d. Nibco-Globe style with isolation valve

8. Calibrated Balancing Valves:
   b. Presso.
   c. Gerand "Balvalve Indicator"
   d. Griswold “Quickset”

9. Flow Meters:
   a. Onicon F3000

2.2 REMOTE READING DIAL THERMOMETERS:

   A. General: Provide remote reading dial thermometers of materials, capacities, and ranges indicated, designed and constructed for use in service indicated.
   B. Type: Vapor tension.
   C. Case: Drawn steel or brass, glass lens, 4-1/2 inch diameter.
   D. Movement: Brass, precision geared.
   E. Tubing: Bronze double braided armor over copper capillary, length to suit installation.
   F. Bulb: Copper with separable socket for liquids, averaging element for air.
   G. Accuracy: + or - one scale division.
   H. Range: Conform to the following:

      1. Hot Water: 30 degree - 240 degree F (0 degree - 115 degree C).
      2. Chilled Water: 30 degree - 180 degree F (0 degree - 85 degree C).
      3. Air: 30 degree - 180 degree F (0 degree - 85 degree C).

2.3 DIAL TYPE INSERTION THERMOMETERS:

   A. General: Provide dial type insertion thermometers of materials, capacities, and ranges indicated, designed and constructed for use in service indicated.
   B. Type: Bi-metal, stainless steel, shock-proof, case and stem, 1 inch diameter dial, dust and leak proof, 1/8 inch diameter stem with nominal length of 5 inch. Provide in individual case.
   C. Accuracy: 0.5 percent of dial range.
D. Range: Conform to the following:

1. Hot Water: 0 degrees - 220 degrees F (-10 degrees - 110 degrees C).
2. Chilled Water: 25 degrees - 125 degrees F (-10 degrees - 110 degrees C).

2.4 PHOTOVOLTAIC DIGITAL THERMOMETERS:

A. Case: High image ABS, with photovoltaic power cell and digital readout.
B. Range: Selectable between -40-300 degrees F / -40-150 degrees F, displayed to 0.1 degrees.
C. Accuracy: 1 percent of reading or 1 degrees F, whichever is greater. Recalibratable via internal potentiometer. Not effected by ambient temperature.
D. Ambient light required: 10 lux
E. Display update: 10 seconds
F. Stem: Compatibly with standard thermowell for piping applications, or sampling with flange for air duct applications.

2.5 THERMOMETER WELLS:

A. General: Provide thermometer wells constructed of brass or stainless steel, pressure rated to match piping system design pressure or pressure gauge. Provide 2 inch extension for insulated piping. Provide cap nut with chain fastened permanently to thermometer well.

2.6 TEMPERATURE AND PRESSURE GAUGE CONNECTOR PLUGS:

A. General: Provide temperature gauge connector plugs pressure rated for 600 psig and -20°F to 300°F. Construct of brass and finish in nickel-plate, equip with ½ inch NPS fitting, with self-sealing valve core type neoprene gasketed orifice suitable for inserting 1/8 inch O.D. probe assembly from dial type insertion thermometer or pressure gauge. Equip orifice with gasketed screw cap and chain. Provide extension, length equal to insulation thickness, for insulated piping.

2.7 PRESSURE GAUGES:

A. General: Provide pressure gauges of materials, capacities, and ranges indicated, designed and constructed for use in service indicated.
B. Type: General use, 1 percent accuracy, ANSI B40.1 grade A, phospher bronze bourdon type, bottom connection.
C. Case: Drawn steel or brass, glass lens, 4-1/2inch diameter. Provide individual shock proof case.
D. Connector: Brass with 1/4inch male NPT. Provide protective syphon when used for steam service.
E. Scale: White coated aluminum, with permanently etched markings.
F. Range: Conform to the following:

1. Vacuum: 30 inches Hg - 15 psi.
2. Water: 0 - 100 psi.

2.8 PRESSURE GAUGE COCKS:

A. General: Provide pressure gauge cocks between pressure gauges and gauge tees on piping systems. Gauge cock shall be ¼ inch female NPT on each end ball valve as specified in Section 15100 - Valves.
B. Syphon: ¼ inch straight coil constructed of brass tubing with ¼ inch male NPT on each end.

C. Snubber: ¼ inch brass bushing with corrosion resistant porous metal disc, through which pressure fluid is filtered. Select disc material for fluid served and pressure rating.

2.9 CALIBRATED BALANCE VALVES:

A. General: Provide as indicated, calibrated balance valves equipped with readout valves to facilitate connecting of differential pressure meter to balance valves. Equip each readout port with a quick connect valve designed to minimize system fluid loss during monitoring process. Provide balance valves with preformed insulation suitable for use on heating and cooling systems, and to protect balance valves during shipment.

B. Design, variable orifice type:
   2. Multiple turns of handwheel from full closed to full open.
   4. Schraeder type taps upstream and downstream.
   5. Memory stop device to allow valve to be returned to balanced position after being closed. (Note: this does not take the place of isolation valves shown on drawings)
   6. Provide slide rule type flow calculator, include in Operation and Maintenance Manual.

C. Design, valve and venturi type:
   1. Ball or butterfly type valve.
   2. Bubble-tight shut-off.
   3. Fixed venturi, upstream of valve.
   4. Schraeder type taps on venturi, upstream and downstream.
   5. Memory stop device to allow valve to be returned to balanced position after being closed. (Note: this does not take the place of isolation valves shown on drawings)
   6. Provide metal tag with flow curve for each valve.

2.10 FLOW METER READ-OUT KITS:

A. Provide flow meter read-out kits with bellows type differential pressure element and minimum 5 inch diameter indicating dial.

B. Design pressure elements for full scale pressure differential of 50 inches or 100 inches water gauge. Design shall incorporate rupture-proof metal beryllium or stainless steel bellows and torque tube drive requiring no lubrication. Design forged bodies for not less than 150 percent of maximum surge pressure, fully protected against surges, with full provision for venting and draining. Provide integral, adjustable pulsation dampers.

C. Dials of portable meters shall have square root scales not less than 12 inches in developed length. Dials shall read from 0 to 10 gpm to which multiplier is to be applied, as required; also provide with uniform scale reading from 0 inches to 10 inches w.g., to which multiplier of 10 to be applied (100 inches at full scale), or from 0 inches to 5 inches w.g., to which multiplier of 10 is to be applied (50 inches at full scale).

D. Engineer and manufacture in accordance with ASME recommendations for flowmeters. Provide portable meters with overall accuracy of + 5 percent.
E. **Provide flow meter with factory-fabricated carrying case with integral carrying handle.** Case shall be fitted to hold meter and following accessories.

1. Two 10 feet lengths of connecting hose with suitable female connectors for connecting to venturi tube pressure tap nipples. Design hose for operating pressure of minimum of 150 percent of maximum system operating pressure.

2. Completely assembled 3-value manifold with 2 block valves and vent and drain valves shall be piped and mounted on base, which shall be designed for use laying flat on stationary base.

3. Bound set of descriptive bulletins, installation and operating instructions, parts list, and set of curves showing flow verses pressure differential for each orifice or venturi tube with which meter is to be used.

4. Metal instruction plate, secured inside cover, illustrating use of meter. Deliver meter with case to Owner.

**PART 3 EXECUTION**

3.1 **INSPECTION:**

A. Examine areas and conditions under which meters and gauges are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 **INSTALLATION OF THERMOMETERS:**

A. General: Install thermometers in vertical upright position, and tilted so as to be easily read by observer standing on floor.

B. Locations: Install in the following locations where shown on details, and elsewhere as indicated:

1. At inlet and outlet of each domestic boiler.

C. Remote Reading Dial Thermometers: Install on control panels as indicated. Run tubing between panel and thermometer bulb, adequately supported to prevent kinks. Select tubing length so as to not require coiling of tubing.

D. Thermometer Wells: Install in piping tee where indicated, in vertical upright position. Fill well with oil or graphite, secure cap.

E. Temperature Gauge Connector Plugs: Install in piping tee where indicated, located on pipe at most readable position. Secure cap. Provide portable temperature gauge for each plug connection.

3.3 **INSTALLATION OF PRESSURE GAUGES:**

A. General: Install pressure gauges in piping tee with pressure gauge cock, located on pipe at most readable position.

B. Locations: Install in the following locations, and elsewhere as indicated:

1. At suction and discharge of each pump.
2. At discharge of each pressure reducing valve.
3. At water service outlet.
4. At inlet and outlet of water cooled condensers and refrigerant cooled chillers.
C. Pressure Gauge Cocks: Install in piping tee with snubber. Install syphon for steam pressure gauges.

D. Pressure Gauge Connector Plugs: Install in piping tee where indicated, located on pipe at most readable position. Secure cap. Provide portable pressure gauge for each plug connection.

3.4 INSTALLATION OF FLOW MEASURING METERS:

A. General: Install flow measuring meters on piping systems located in accessible locations at most readable position.

B. Locations: Install in the following locations, and elsewhere as indicated.
   1. At discharge of each pump.
   2. At inlet of each hydronic coil.

C. Calibrated Balance Valves: Install on piping with readout valves in vertical upright position. Maintain minimum length of straight unrestricted piping equivalent to 3 pipe diameters upstream of valve.

3.5 INSTALLATION OF P/T PORTS:

A. Provide ports at mains where branches split or converge to trouble shoot system.

3.6 ADJUSTING AND CLEANING:

A. Adjusting: Adjust faces of meters and gauges to proper angle for best visibility.

B. Cleaning: Clean windows of meters and gauges and factory-finished surfaces. Replace cracked or broken windows, repair any scratched or marred surfaces with manufacturer's touch-up paint.

END OF SECTION 22 05 19
SECTION 22 05 23
VALVES

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. This Section includes general duty valves common to most mechanical piping systems.

B. Valves tags and charts are specified in Division 22 Section "Mechanical Identification."

1.2 SUBMITTALS:

A. Product Data: including body material, valve design, pressure and temperature classification, end connection details, seating materials, trim material and arrangement, dimensions and required clearances, and installation instructions. Submittals must indicate compliance with applicable MSS (Manufacturer Standardization Society) standards.

1.3 QUALITY ASSURANCE:

A. Single Source Responsibility: Comply with the requirements specified in Division 22 Section "Basic Mechanical Requirements," under "Product Options."

B. MSS Standard Practices: Comply with the following standards for valves:

1. MSS SP-45: Bypass and Drain Connection Standard
2. MSS SP-67: Butterfly Valves
3. MSS SP-70: Cast Iron Gate Valves, Flanged and Threaded Ends
4. MSS SP-71: Cast Iron Swing Check Valves, Flanged and Threaded Ends
5. MSS-SP-110: Ball Valves with Flanged or Butt-Welding Ends for General Service
6. MSS SP-78: Cast Iron Plug Valves, Flanged and Threaded Ends
7. MSS SP-80: Bronze Gate, Globe Angle and Check Valves
8. MSS SP-84: Steel Valves - Socket Welding and Threaded Ends
9. MSS SP-85: Cast Iron Globe and Angle Valves, Flanged and Threaded Ends
10. MSS SP-92: MSS Valve User Guide

C. Solenoid valves shall be UL listed, FM and CSA approved.

1.4 DELIVERY, STORAGE, AND HANDLING:

A. Preparation For Transport: Prepare valves for shipping as follows:

1. Ensure valves are dry and internally protected against rusting and galvanic corrosion.

2. Protect valve ends against mechanical damage to threads, flange faces, and weld end preps.

3. Set valves in best position for handling. Globe, valves shall be closed to prevent rattling; ball and plug valves shall be open to minimize exposure of functional surfaces; and swing check valves shall be blocked in either closed or open position.

B. Storage: Use the following precautions during storage:

1. Valves shall be stored and protected against all dirt, debris and foreign material at all times.
2. Do not remove valve end protectors unless necessary for inspection; then reinstall for storage.

3. Protect valves against weather. Where practical store valves indoors. Maintain valve temperature higher than the ambient dew point temperature. If outdoor storage is necessary, support valves off the ground or pavement and protect in watertight enclosures.

C. Handling: Valves whose size requires handling by crane or lift shall be slung or rigged to avoid damage to exposed valve parts. Handwheels and stems, in particular, shall not be used as lifting or rigging points.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Manufacturer: Subject to compliance with requirements, provide products by the manufacturers listed.

1. Ball Valves:
   a. Conbraco (Apollo)
   b. Milwaukee
   c. Watts
   d. Jomar

2. Swing Check Valves
   a. Conbraco
   b. Grinnell Corp.
   c. Nibco
   d. Watts (screwed)
   e. Stockham

3. Non-Slam Check Valves:
   a. Centerline
   b. Keystone
   c. Metraflex
   d. Techno Corporation
   e. Nibco
   f. Val-Matic
   g. Milwaukee
   h. Stockham
   i. Golden Anderson

4. Lift Check Valves:
   a. Conbraco
   b. Metraflex
   c. Milwaukee
   d. Nibco
   e. Stockham

2.2 VALVE FEATURES:

A. General: Comply with MSS-92 1980 "Valve Users Manual".
B. Valve Design: Valves shall have rising stem, or rising stem outside screw and yoke design; except, non-rising stem valves may be used where headroom prevents full operation of rising stem valves.

C. Sizes: Unless otherwise indicated, provide valves of same size as upstream pipe size. (Control valves shall be sized for required flow.)

D. Operators: Provide the following special operator features:
   1. Handwheels, fastened to valve stem for valves other than quarter turn.
   2. Lever Handle on quarter turn valves 6 inch and smaller, except plug valves. Provide a wrench for every plug valve.
   3. Chainwheel operators for valves 2-1/2 inch and larger that are installed 96 inches or higher above finished floor elevation. Provide chains to an elevation of 6'-0" above finished floor elevation.
   4. Worm gear operators of an enclosed weather-proof design shall be provided on all quarter turn valves 8 inches and larger.

E. Extended Stems: Where insulation is indicated or specified, provide extended stems to allow full operation of the valve without interference by the insulation.

F. Bypass and Drain Connections: Comply with MSS SP-45.

G. End Connections: As specified in the individual valves specifications.
      a. Caution: Where soldered end connections are used, use solder having a melting point below 840 degrees F for gate, globe, and check valves and below 421 degrees F for ball valves.

2.3 BALL VALVES:

A. Ball Valves – 1 inch and Smaller: 150 WSP, 600 WOG, rated for 150 PSI at 350 degrees F, two piece end entry body style, bronze body conforming to ASTM B584, full port solid bored-hole, stainless steel ball and stem, 15 percent glass reinforced PTFE seats, PTFE packing, adjustable packing nut blow-out proof stem, vinyl covered steel handle. Provide solder ends or threaded ends to match piping system. Apollo 77-200

B. Ball Valves 1-1/4 inch and larger and for all silver soldered or brazed lines: ANSI B16.34, 150 WSP, 600 WOG, rated for 150 PSI at 350 degrees F. Three piece body style, bronze body conforming to ASTM B584, full port, solid, bored-hole stainless steel ball and stem of ASTM A276 type 316, 15 percent glass reinforced RTFE seats, RTFE packing and blow out proof stem, vinyl coated steel handle. Provide solder ends or threaded ends to match piping material system. Apollo 82-200.

C. Ball valve options/accessories: Provide the following as required or as specifically indicated:
1. Tee handle for tight fit applications (within enclosures, etc.).
2. Locking handle.
3. Drain.
4. Stem extension.
5. Mounting pads.

2.4 CHECK VALVES:

A. Plumbing systems shall have poly-coated check valves and strainers.

B. Swing Check Valves - 2-1/2 Inch and Smaller: MSS SP-80; Class 125/150 WSP 200/300, cast bronze body and cap conforming to ASTM B 62, bronze, horizontal swing design, Y-pattern, with a bronze disc, stainless steel pin and having threaded or solder ends. Class 150 valves meeting the above specifications may be used where pressure requires or Class 125 are not available.

C. Swing Check Valves - 2-1/2 to 3 Inch: MSS SP-71; Class 125 /250 (Class 175 FM approved for fire protection piping systems), cast iron body and bolted cap conforming to ASTM A 126, Class B; horizontal swing, with a bronze disc or cast iron disc with bronze disc ring, and flanged ends. Valve shall be capable of being refitted while the valve remains in the line. For sewage ejector and sump pump discharge swing check valves 2-1/2 inches and larger, provide outside lever with weight or spring to assist disc to close rapidly.

D. Non-Slam Check Valves - 2 Inch and smaller: Bronze body, 200 psi @ 250 degrees F., threaded ends, resilient seats, center guided spring loaded disk.

E. Non-Slam Check Valves - 2-1/2 Inch and Larger: Class 250 cast iron or stainless steel body, replaceable lapped bronze seat and balanced twin bronze flappers or bronze center guided disc and stainless steel trim. Valve shall be designed to open and close at approximately one foot differential pressure. Twin flappers or center guided disc shall be loaded with a stainless steel spring to assure even non-slam checking action. Seals shall be EPDM.

F. Lift Check Valves 2 Inch and Smaller: Class 125, cast bronze body and cap conforming to ASTM B 62, horizontal or angle pattern, lift type valve, with stainless steel spring, bronze disc holder with renewable "Teflon" disc, and threaded ends. Valve shall be capable of being refitted and ground while the valve remains in the line.

2.5 DRAIN VALVES:

A. For HVAC and plumbing hydronic systems provide ball valve with threaded hose end, and cap with chain.

Apollo Fig. 78-100/78-200 Series

PART 3 - EXECUTION

3.1 EXAMINATION:

A. Install valves in accordance with manufacturers instructions.

B. Examine valve interior through the end ports, for cleanliness, freedom from foreign matter and corrosion. Remove special packing materials, such as blocks used which prevents disc movement during shipping and handling.
C. Actuate valve through an open-close and close-open cycle. Examine functionally significant features, such as guides and seats made accessible by such actuation. Following examination, return the valve closure member to the position in which it was shipped.

D. Examine threads on both the valve and the mating pipe for form (out-of-round or local indentation) and cleanliness.

E. Examine mating flange faces for conditions which might cause leakage. Check bolting for proper size, length, and material. Check gasket material for proper size and material, and for freedom from defects and damage.

F. Prior to valve installation, examine the piping for cleanliness, freedom from foreign materials, and proper alignment.

G. Locate valves in accessible locations with adequate clearance around hand wheels or levers for easy operation.

H. Install isolation valves within 5 feet of the equipment or appliance served.

3.2 VALVE SELECTION:

A. Selection of Valve Ends (Pipe Connections): Except as otherwise indicated, select valves with the following ends or types of pipe/tube connections:

1. Copper Tube Size 1-1/2 Inch and Smaller: Solder ends, except in heating hot water and low pressure steam service which shall have threaded ends.

2. Copper Tube Size 1-1/2 Inch and Larger: Brazed ends, except in heating hot water and low pressure steam service which shall have threaded ends.

3. Steel Pipe Sizes 2 Inch and Smaller: Threaded or grooved-end.

4. Steel Pipe Sizes 2-1/2 Inch and Larger: Flanged or grooved end.

5. At all piping hot taps provide a gate valve with the hot tap and a butterfly valve for shut-off service. Hot taps shall be provided only where approved by the Engineer.

3.3 VALVE INSTALLATIONS:

Valve Application Table

(Where sizes overlap, contractor has choice of either type)

<table>
<thead>
<tr>
<th>SERVICE</th>
<th>VALVE TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plumbing Water Services; 4&quot; or smaller</td>
<td>Ball Valve</td>
</tr>
<tr>
<td>Plumbing Pressure Reducing Bypass; all sizes</td>
<td>Ball Valves</td>
</tr>
<tr>
<td>Plumbing Balancing Service; 2&quot; and smaller</td>
<td>Calibrated Balancing Valve</td>
</tr>
<tr>
<td>Plumbing Balancing Service; 2-1/2&quot; and larger</td>
<td>Eccentric Plug Valve</td>
</tr>
</tbody>
</table>
A. Locate valves for easy access and provide separate support where necessary.

B. Install valves and unions for each fixture and item of equipment in a manner to allow equipment removal without system shut-down. Unions are not required on flanged devices.

C. Gate and globe valves shall be installed with the stem in the upright position. In overhead horizontal piping, ball valves shall be installed with the handle in the side or bottom of the piping. Butterfly valves shall be installed with the stem within 45 degrees of the horizontal position. The handle of quarter turn valves shall open in the direction of flow. Quarter turn valves with hand wheels or chain wheels shall be located so that the position indicator is visible from the floor without the use of a ladder or climbing on equipment or piping.

D. Installation of Check Valves: Install for proper direction of flow as follows:
   1. Swing Check Valves: Install in horizontal position with hinge pin level.
   2. Wafer Check Valves: Install between 2 flanges in horizontal or vertical upward flow position.
   3. Lift Check Valve: Install in piping line with stem upright and plumb.

3.4 SOLDER CONNECTIONS (1-1/2” AND SMALLER):

A. Cut tube square and to exact lengths.

B. Clean end of tube to depth of valve socket, using steel wool, sand cloth, or a steel wire brush to a bright finish. Clean valve socket in same manner.

C. Apply proper soldering flux in an even coat to inside of valve socket and outside of tube.

D. Open gate and globe valves to fully open position.

E. Remove the cap and disc holder of swing check valves with composition discs.

F. Insert tube into valve socket making sure the end rests against the shoulder inside valve. Rotate tube or valve slightly to insure even distribution of the flux.

G. Apply heat evenly to outside of valve around joint until solder will melt upon contact. Feed solder until it completely fills the joint around tube. Avoid hot spots or overheating the valve. Once the solder starts cooling, remove excess amounts around the joint with a cloth or brush.

3.5 BRAZED CONNECTIONS (2” AND LARGER):

A. Protect valves from temperatures which exceed the valve material temperature limitations as recommended by the valve manufacturer.

B. Disassemble 3 piece ball valves prior to brazing.

3.6 THREADED CONNECTIONS:

A. Note the internal length of threads in valve ends, and proximity of valve internal seat or wall, to determine how far pipe should be threaded into valve.

B. Align threads at point of assembly.
C. Apply appropriate tape or thread compound to the external pipe threads (except where dry seal threading is specified).

D. Assemble joint wrench tight. Wrench on valve shall be on the valve end into which the pipe is being threaded.

3.7 FLANGED CONNECTIONS:

A. Align flanges surfaces parallel.

B. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly using a torque wrench.

3.8 FIELD QUALITY CONTROL:

A. Testing: After piping systems have been tested and put into service, but before final adjusting and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks; replace valve if leak persists.

3.9 ADJUSTING AND CLEANING:

A. Cleaning: Clean mill scale, grease, and protective coatings from exterior of valves and prepare to receive finish painting or insulation.

END OF SECTION 22 05 23
PART 1 - GENERAL

1.1 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of supports and anchors, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Codes and Standards:

1. Regulatory Requirements: Comply with applicable plumbing codes pertaining to product materials and installation of supports and anchors.

2. NFPA Compliance: Hangers and supports shall comply with NFPA standard No. 13 when used as a component of a fire protection system and NFPA Standard No. 14 when used as a component of a standpipe system.

3. UL and FM Compliance: Hangers, supports, and components shall be listed and labeled by UL and FM where used for fire protection piping systems.

4. Duct Hangers: SMACNA Duct Manuals

5. MSS Standard Compliance:

   a. Provide pipe hangers and supports of which materials, design, and manufacture comply with MSS SP-69.

1.2 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data, including installation instructions for each type of support and anchor. Submit pipe hanger and support schedule showing Manufacturer's figure number, size, location, and features for each required pipe hanger and support.

B. Shop Drawings: Submit manufacturer's assembly-type shop drawings for each type of support and anchor, indicating dimensions, weights, required clearances, and methods of assembly of components.

C. Product certificates signed by the manufacturer of hangers and supports certifying that their products meet the specified requirements.

D. Maintenance Data: Submit maintenance data and parts list for each type of support and anchor. Include this data, product data, and shop drawings in maintenance manual; in accordance with requirements of Division 22.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Manufacturer: Subject to compliance with requirements, provide products by one of the following:

1. Pipe Hangers and Supports:
2. SADDLES, SHIELD AND THERMAL SHIELD INSERTS:
   a. ANVIL International
   b. Pipe Shields, Inc.
   c. B-Line
   d. Insulated Saddle Shield Insert Product Inc.

3. ROOF EQUIPMENT SUPPORTS:
   a. Custom Curb, Inc.
   b. Pate Co.
   c. Thycurb Div.; Thybar Corp.
   d. Vent Products, Inc.

4. CONCRETE INSERTS AND ANCHORS:
   a. Unistrut Metal Framing Systems
   b. Power-Strut
   c. ITW Ramset/Red Head
   d. Hilti
   e. B-Line

2.2 PIPE HANGERS & SUPPORTS:

A. Hangers and support components shall be factory fabricated of materials, design, and manufacturer complying with MSS SP-69.

1. Components shall have galvanized coatings where installed for piping and equipment that will not have field-applied finish.

2. Pipe attachments shall have nonmetallic coating for electrolytic protection where attachments are in direct contact with copper tubing.

B. Adjustable Clevis Hanger: MSS Type.

1. Steel Pipe, size 3/8" thru 30", Type 1.
2. Non-insulated Copper Pipe, size 1/2" thru 4", Type 1. (PVC Coated)

C. Adjustable Swivel Ring for Non-insulated Pipe: MSS Type.

1. Steel Pipe, size 1/2" thru 8", Type 7.
2. Copper Pipe, size 1/2" thru 4", Type 7 (PVC Coated)

D. Pipe Clamps: MSS Type.

2. Copper Pipe, size 1/2" thru 4", Type 8 (PVC Coated).
E. U Bolts: MSS Type.

1. Steel Pipe, size 1/2” thru 30" Type 24
2. Copper Pipe, size 1/2” thru 8", Type 24 (PVC Coated).

F. Straps: MSS Type 26.

G. Pipe Stanchion Saddle: MSS Type 37.

H. Yoke & Roller Hanger: MSS Type 43

I. Hanger Rods: Continuous threaded steel, sizes as specified.

J. Hangers:

1. Hot Pipes:
   a. 1/2" through 1-1/2": Adjustable wrought steel ring.
   b. 2" through 5": Adjustable wrought steel clevis.
   c. 6" and Over: Adjustable steel yoke and cast iron roll.

2. Cold Pipes:
   a. 1/2" through 1-1/2": Adjustable wrought steel ring.
   b. 2" and Over: Adjustable wrought steel clevis.

3. Multiple or Trapeze: Structural steel channel (with web vertical and engineered for the specific applications), with welded spacers and hanger rods. Provide cast iron roll and base plate for hot pipe sizes six inches and over. Provide hanger rods one size larger than for largest pipe in trapeze. If the deflection at center of trapeze exceeds 1/360 of the distance between the end hangers, install an additional hanger at mid-span or use a larger channel.

K. Wall Supports for Horizontal Steel Pipe:

1. ½ inch through 4 inches: Offset or straight j-hook.

2. 4 inches and Over: Welded steel bracket Type 31, 32 or 33 and wrought steel clamp. Provide adjustable steel yoke and cast iron roll Type 44 for hot pipe 200°F and over and for sizes six inches and over.

L. Supports for Vertical Pipe: Steel riser clamp. Type 8.

M. Upper Attachments:

1. For attaching hanger rods to structural steel I-beams:
   a. Provide adjustable beam clamp, MSS-Type 21. Attach to bottom flange of beam.

2. For attaching hanger rods to bar joists:
   a. When bottom chord is constructed of structural steel angles, provide square washer. Place hanger rod between backs of the two angles and support with the washer and dual locking nuts on top of the angles. Spot weld washer to angles.
2.3 CONCRETE INSERTS AND ANCHORS:

A. Inserts: Case shall be of galvanized carbon steel with square threaded concrete insert nut for hanger rod connection; top lugs for reinforcing rods, nail holes for attaching to forms. This type of upper attachment is to be used for all areas having poured in place concrete construction.

1. Size inserts to suit threaded hanger rods.

B. Provide fasteners attached to concrete ceilings that are vibration and shock resistant. Provide hangers for piping attached to concrete construction with one of the following types.

1. Concrete insert per MSS SP 69, Type 18.

2. Powder driven fasteners subject to approval of Architect and Structural Engineer. Each fastener shall be capable of holding a test load of 1000 pounds whereas the actual load shall not exceed 50 pounds.

3. Self-drilling expansion shields. The load applied shall not exceed one-fourth the proof test load required.

4. Machine bolt expansion anchor. The load applied shall not exceed one-fourth the proof test load required.

C. Anchors: Carbon steel, zinc plated and coated with a clear chromate finish when exposed to view (i.e. lab corridors, basement labs). Installation shall be in holes drilled with carbide-tipped drill bits or by use of self-drilling anchors.

1. Provide anchors suitable for the location of installation and designed to withstand all forces and movements acting in the anchor. Manufacture pipe anchors in accordance with MSS SP 69. Provide a safety factor of four for the anchor installation.

2.4 SADDLES AND THERMAL SHIELD INSERTS:

A. Protection Saddles: MSS Type 39; fill interior voids with segments of insulation matching adjoining insulation.

B. Protection Shields: MSS Type 40; 180 degrees arc, galvanized steel, minimum 12 inches long, to prevent crushing of insulation.

C. Thermal Shield Inserts: Provide 100-psi minimum compressive strength, waterproof, asbestos free calcium silicate, encased with a sheet metal enclosure. Insert and shield shall cover the entire circumference or the bottom half circumference of the pipe as required by Part 3 of this Specification, and shall be of length recommended by the manufacturer for pipe size and thickness of insulation. For cold piping, calcium silicate shall extend beyond the sheet metal shield to allow overlap of the vapor barrier. Where piping 4 inches and larger is supported on trapeze or pipe rollers, provide double thickness shields. For piping 12 inches and over, provide 600 psi calcium silicate structural insert.
PART 3 EXECUTION

3.1 INSPECTION:

A. Examine areas and conditions under which supports and anchors are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 PREPARATION:

A. Proceed with installation of hangers, supports and anchors only after required building structural work has been completed in areas where the work is to be installed. Correct inadequacies including (but not limited to) proper placement of inserts, anchors and other building structural attachments. Review Structural Drawings to obtain structural support limitations.

B. Prior to installation of hangers, supports, anchors and associated work, Installer shall meet at project site with Contractor, installer of each component of associated work, inspection and testing agency representatives (if any), installers of other work requiring coordination with work of this section and Architect/Engineer for purpose of reviewing material selections and procedures to be followed in performing the work in compliance with requirements specified. Provide Shop Drawing showing method and support locations from structure.

3.3 INSTALLATION OF BUILDING ATTACHMENTS:

A. Install building attachments within concrete or on structural steel. Space attachments within maximum piping span length indicated in MSS SP-69. Install additional attachments at concentrated loads, including valves, flanges, guides, strainers, expansion joints, and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten insert to forms. Where concrete with compressive strength less than 2500 psi is indicated, install reinforcing bars through openings at top of inserts.

B. New Construction:

1. Use inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams wherever practicable.

2. Set inserts in position in advance of concrete work. Provide reinforcement rod in concrete for inserts carrying pipe over 4 inches or ducts over 60 inches wide.

3. Where concrete slabs form finished ceiling, finish inserts flush with slab surface.

4. Where inserts are omitted drill through concrete slab from below and provide rod with recessed square steel plate and nut above slab if construction above permits.

3.4 INSTALLATION OF HANGERS AND SUPPORTS:

A. Install hangers, supports, clamps and attachments to support piping properly from building structure; comply with MSS SP-69. Arrange for grouping of parallel runs of horizontal piping to be supported together on field fabricated, heavy-duty trapeze hangers where possible. Install supports with maximum spacings complying with MSS SP-69. Where piping of various sizes is supported together by trapeze hangers, space hangers for smallest pipe size or install intermediate supports for smaller diameter pipe. Do not use wire or perforated metal to support piping, and do not support piping from other piping.

B. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers and other accessories.
C. Support fire-water piping independently from other piping systems.

D. Prevent electrolysis and abrasion in support of copper tubing by use of hangers and supports which are plastic coated, or with EPDM isolation strips. Duct tape or copper coated hangers are not acceptable.

E. Install hangers and supports to allow controlled movement of piping systems, to permit freedom of movement between pipe anchors, to facilitate action of expansion joints, expansion loops, expansion bends and similar units and within 1'-0" of each horizontal elbow.

F. Load Distribution: Install hangers and supports so that piping live and dead loading and stresses from movement will not be transmitted to connected equipment.

G. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes, and so that maximum pipe deflections allowed by ANSI B31.9 Building Services Piping Code is not exceeded.

H. Insulated Piping: Comply with the following installation requirements.

1. Clamps: Attach clamps, including spacers (if any), to piping with clamps projecting through insulation; do not exceed pipe stresses allowed by ANSI B31.

2. Saddles: Install Protection saddles where supported by pipe rollers. Fill interior voids with segments of insulation that match adjoining pipe insulation.

3. Shields: Install galvanized steel protection shields, on all insulated piping 2 inches and less, except where required to be clamped. Where necessary to prevent dislocation, strap shield to pipe with wire ties or "Zip Strips".

4. Thermal Inserts: Provide thermal shield inserts at all supports for all insulated piping over 2 inches and for all piping required to be clamped. Provide 180 percent inserts at clevis and roller hangers. Provide 360 percent inserts for all trapeze and clamped supports.

I. Install horizontal pressurized piping with the following minimum rod sizes and maximum spacing:

<table>
<thead>
<tr>
<th>SIZE (NPS)</th>
<th>MAX. SPAN IN FEET</th>
<th>MIN. ROD SIZE-INCHES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>Copper</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>1-1/2</td>
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<td>16</td>
</tr>
<tr>
<td>10</td>
<td>22</td>
<td>18</td>
</tr>
</tbody>
</table>
J. Install steel natural gas piping with the following minimum rod size and maximum spacing:

<table>
<thead>
<tr>
<th>SIZE (NPS)</th>
<th>MAX. SPAN IN FEET</th>
<th>MIN. ROD SIZE - INCHES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2</td>
<td>6</td>
<td>3/8</td>
</tr>
<tr>
<td>3/4 TO 1</td>
<td>8</td>
<td>3/8</td>
</tr>
<tr>
<td>1-1/4</td>
<td>10</td>
<td>3/8</td>
</tr>
<tr>
<td>1-1/2</td>
<td>10</td>
<td>3/8</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
<td>3/8</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>½</td>
</tr>
<tr>
<td>5</td>
<td>19</td>
<td>5/8</td>
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<tr>
<td>6</td>
<td>21</td>
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<td>10</td>
<td>26</td>
<td>7/8</td>
</tr>
<tr>
<td>12</td>
<td>30</td>
<td>7/8</td>
</tr>
</tbody>
</table>

Vertical, all sizes every floor level

K. Install laboratory gas piping hangers with the following maximum spacing.

1. 1/2" Pipe Size: 6' O.C.
2. 3/4" Pipe Size: 7' O.C., 1" pipe size: 8'
3. 1-1/4" or Larger Pipe Size: 9' O.C.
4. 1-1/2" and larger: 10'
5. Vertical Piping: Every floor level.

L. Support horizontal cast iron pipe as follows:

1. Hub & Spigot: All sizes.
   a. 10 ft. max spacing: min of one (1) hanger per pipe section close to joint on the barrel. Also at change of direction and branch connections.
   b. Support vertical cast iron pipe at each story height and at its base. Secure vertical hub and spigot pipe immediately below the hub.
   c. Use hanger rods same size as for steel pipe.
2. No-Hub: All sizes
   a. With Clamp-All and Anaheim Series 4000 stainless steel couplings and MG cast iron couplings: one hanger to each joint.
   b. With all other stainless steel band type couplings: one hanger to each side of joint.
   c. Support all horizontal cast iron pipe within 18 inches of each joint and with 5 feet maximum spacing between hangers, except that pipe exceeding 5 feet in length shall be supported at intervals no greater than 10 feet.
d. Use hanger rods same size as for steel pipe.

e. Support vertical cast iron pipe at each story height and at its base. Support vertical no-hub pipe so that the weight is carried from the pipe to the support and not from the joint to the support.

M. Place a hanger within one foot of each horizontal elbow.

N. Use hangers which are vertically adjustable 1-1/2 inch minimum after piping is erected.

O. Support vertical steel and copper piping at every story height but at not more than 15 foot intervals for steel and 10 feet for copper.

P. Where several pipes can be installed in parallel and at same elevation, provide trapeze hangers.

Q. Where practical, support riser piping independently of connected horizontal piping.

R. Each pipe drop to equipment shall be adequately supported. All supporting lugs or guides shall be securely anchored to the building structure.

S. Securely anchor and support plumbing domestic water piping in chases or walls. Use factory manufactured clamps and brackets connected to fixture s, waste/vent piping or brackets connected to studs. Wires or straps will not be permitted.

1. When copper supplies are connected to flush valves, support the tubing by the studs or by a fixture, not by clamping to waste/vent piping.

2. Prevent copper tubes from making contact with steel brackets using fire retardant polyethylene inserts or other dielectric insulating material. Duct tape shall not be used.

T. Install anchors and fasteners in accordance with manufacturer's recommendations and the following:

1. In the event a self-drilling expansion shield or machine bolt expansion shield is considered to have been installed improperly, the Contractor shall make an acceptable replacement or demonstrate the stability of the anchor by performing an on-site test under which the anchor will be subjected to a load equal to twice the actual load.

2. Powder-driven fasteners may be used only where they will be concealed after the construction is complete. Where an occasional fastener appears to be improperly installed, additional fastener(s) shall be driven nearby (not closer than 6 inches) in undisturbed concrete. Where it is considered that many fasteners are improperly installed, the Contractor shall test load any 50 successively driven fasteners. If 10 percent or more of these fasteners fail, the Contractor shall utilize other fastening means as approved and at no additional cost to the Owner.

3. Hangers for piping and ducts shall be attached to cellular steel floor decks with steel plates and bolted rod conforming to the steel deck manufacturer's requirements. Where the individual hanger load exceeds the capacity of a single floor deck attachment, steel angles, beams or channels shall be provided to span the number of floor deck attachments required.

4. Welding may be used for securing hangers to steel structural members. Welded attachments shall be designed so that the fiber stress at any point of the weld or attachment will not exceed the fiber stress in the hanger rod.

U. Place a hanger within 6” of both sides of a control valve.
V. Within walls, support vertical pipe every 6 feet where pipe supplies a fixture.

W. Pipes on roofs shall be supported by roller supports of adjustable height. Wood blocks and straps are not acceptable for lengths greater than six feet.

3.5 INSTALLATION OF ANCHORS:

A. Install anchors at proper locations to prevent stresses from exceeding those permitted by ANSI B31.9, and to prevent transfer of loading and stresses to connected equipment.

B. Fabricate and install anchor by welding steel shapes, plates and bars to piping and to structure. Comply with ANSI B31.9 and with AWS Standards D1.1.

C. Where expansion compensators are indicated, install anchors in accordance with expansion unit manufacturer's written instructions, to control movement to compensators.

D. Anchor Spacings: Where not otherwise indicated, install anchors at ends of principal pipe-runs, at intermediate points in pipe-runs between expansion loops and bends. Make provisions for preset of anchors as required to accommodate both expansion and contraction of piping. Provide shop drawing for review by Engineer.

3.6 EQUIPMENT SUPPORTS:

A. Fabricate structural steel stands to suspend equipment from structure above or support equipment above floor.

B. Grouting: Place grout under supports for piping and equipment.

C. Concrete bases for the mechanical equipment indoors or outdoors will be provided by the General Contractor only if shown on the architectural or structural drawings. Otherwise, all bases shall be provided by this Contractor.

D. Housekeeping bases shall be 4 inches thick minimum, extended 4 inches beyond machinery bedplates.

E. This Contractor shall be responsible for the proper size and location of all bases and shall furnish all required anchor bolts and sleeves. If bases are provided by the General Contractor, furnish him with templates showing the bolt locations.

F. Equipment shall be secured to the bases with anchor bolts of ample size. Bolts shall have bottom plates and pipe sleeves and shall be securely imbedded in the concrete. All machinery shall be grouted under the entire bearing surface. After grout has set, all wedges, shims and jack bolts shall be removed and the space filled with non-shrinking grout. This Contractor shall provide lead washers at all equipment anchor bolts.

G. Construct equipment supports above floor of structural steel members or steel pipe and fittings. Brace and fasten with flanges bolted to structure.

H. Provide rigid anchors for ducts and pipes immediately after vibration connections to equipment.

3.7 METAL FABRICATION:

A. Cut, drill, and fit miscellaneous metal fabrications for pipe anchors and equipment supports. Install and align fabricated anchors in indicated locations.
B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1 for procedures of manual shielded metal-arc welding, appearance and quality of welds made, methods used in correcting welding work, and the following:
   1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
   2. Obtain fusion without undercut or overlap.
   3. Remove welding flux immediately.
   4. Finish welds at exposed connections so no roughness shows after finishing and contours at welded surfaces match adjacent contours.

3.8 ADJUSTING:

A. Hanger Adjustment: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Touch-Up Painting: Immediately after erection of anchors and supports, clean field welds and abraded areas of shop paint and paint exposed areas with same material as used for shop painting to comply with SSPC-PA-1 requirements for touch-up of field-painted surfaces.
   1. Apply by brush or spray to provide a minimum dry film thickness of 2.0 mils.

C. For galvanized surfaces clean welds bolted connections and abraded areas and apply galvanizing repair paint to comply with ASTM A 780.

END OF SECTION 22 05 29
SECTION 22 05 53
MECHANICAL IDENTIFICATION

PART 1 - GENERAL

1.1 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacturer of identification devices of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Codes and Standards:

   1. ANSI Standards: Comply with ANSI A13.1 for lettering size, length of color field, colors, and viewing angles of identification devices.

   2. ANSI Z53.1 “Safety color code for marking Physical Hazards” ASHRAE.

1.2 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data and installation instructions for each identification material and device required.

B. Schedules: Submit valve schedule for each piping system, typewritten and reproduced on 8-1/2" x 11" bond paper. Tabulate valve number, piping system, system abbreviation (as shown on tag), location of valve (room or space), size of valve, and variations for identification (if any). Only tag valves which are intended for emergency shut-off and similar special uses, such as valve to isolate individual system risers, individual floor branches or building system shut off valves. In addition to mounted copies, furnish extra copies for Maintenance Manuals as specified in Division 22.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Manufacturer: Subject to compliance with requirements, provide products by one of the following:

B. Mechanical Identification:

   2. Seton Name Plate Corp.

2.2 MECHANICAL IDENTIFICATION MATERIALS:

A. General: Provide manufacturer's standard products of categories and types required for each application as referenced in other Division 22 sections. Where more than single type is specified for application, selection is Installer's option, but provide single selection for each product category.

2.3 PAINTED IDENTIFICATION MATERIALS:

A. Stencils: Standard fiberboard stencils, prepared for required applications with letter sizes generally complying with recommendations of ANSI A13.1 for piping or to match existing size in existing building, but not less than 1-1/4" high letters for ductwork and not less than 3/4" high letters for access door signs and similar operational instructions.
B. Stencil Paint: Standard exterior type stenciling enamel; black, except as otherwise indicated; either brushing grade or pressurized spray-can form and grade.

C. Identification Paint: Standard identification enamel of colors indicated or, if not otherwise indicated comply with ANSI A13.1 for colors or to match existing building standard identification.

2.4 PLASTIC PIPE MARKERS:

A. Snap-On Type: Provide manufacturer's standard pre-printed, semi-rigid snap-on, color-coded pipe markers, complying with ANSI A13.1.

B. Insulation: Furnish 1 inch thick molded fiberglass insulation with jacket for each plastic pipe marker to be installed on uninsulated pipes subjected to fluid temperatures of 125 degrees F. (52 degrees C.) or greater. Cut length to extend 2 inches beyond each end of plastic pipe marker.

C. Small Pipes: For external diameters less than 6 inches (including insulation if any), provide full-band pipe markers, with direction of flow arrows, extending 360 degrees around pipe at each location, fastened by one of the following methods:

1. Snap-on application of pre-tensioned semi-rigid plastic pipe marker.
   a. Setmark Type SNA

2. Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 3/4 inch wide; full circle at both ends of pipe marker, tape lapped 1-1/2 inch.

D. Large Pipes: For external diameters of 6 inches and larger (including insulation if any), provide Setmark Type STR, fastened by one of the following methods:

1. Steel spring or non-metallic fasteners.

2. Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 1-1/2 inches wide; full circle at both ends of pipe marker, tape lapped 3 inches.

3. Strapped-to-pipe (or insulation) application of semi-rigid type, with manufacturer's standard stainless steel bands.

E. Pressure Sensitive Markers: Brady Type 350 flexible vinyl film identification markers and tape, with legend, size and color per ANSI A-13.1.

F. Lettering: Comply with piping system nomenclature as specified, scheduled, shown, or to match existing building lettering nomenclature system and abbreviate only as necessary for each application length.

G. Arrows: Print each pipe marker with arrows indicating direction of flow, either integrally with piping system service lettering (to accommodate both directions), or as separate unit of plastic.

2.5 PLASTIC TAPE:

A. General: Provide manufacturer's standard color-coded pressure-sensitive (self-adhesive) vinyl tape, not less than 3 mils thick.

B. Width: Provide 1-1/2 inches wide tape markers on pipes with outside diameters (including insulation, if any) of less than 6 inches, 2-1/2 inches wide tape for larger pipes.
C. Color: Comply with ANSI A13.1, except where another color selection is indicated.

2.6 UNDERGROUND-TYPE PLASTIC LINE MARKERS:

A. General: Manufacturer's standard permanent, bright-colored, continuous-printed plastic tape, intended for direct-burial service; not less than 6 inches wide x 4 mils thick. Provide tape with printing which most accurately indicates type of service of buried pipe.

B. Provide multi-ply tape consisting of solid aluminum foil core between 2-layers of plastic tape.

2.7 ENGRAVED PLASTIC-LAMINATE SIGNS:

A. General: Provide engraving stock melamine plastic laminate, complying with FS L-P-387, in the sizes and thicknesses indicated, engraved with engraver's standard letter style of the sizes and wording indicated, black letters on light contrasting background color except as otherwise indicated, punched for mechanical fastening except where adhesive mounting is necessary because of substrate.

B. Thickness: 1/8 inch, except as otherwise indicated.

C. Fasteners: Self-tapping stainless steel screws, except contact-type permanent adhesive where screws cannot or should not penetrate the substrate.

2.8 PLASTICIZED TAGS:

A. General: Manufacturer's standard pre-printed or partially pre-printed accident-prevention tags, of plasticized card stock with matt finish suitable for writing, approximately 3-1/4 inch x 5-5/8 inch, with brass grommets and wire fasteners, and with appropriate pre-printed wording including large-size primary wording (as examples; DANGER, CAUTION, DO NOT OPERATE).

2.9 LETTERING AND GRAPHICS:

A. General: Coordinate names, abbreviations and other designations used in mechanical identification work, with corresponding designations shown, specified, scheduled and approved by the Owner/Engineer. Provide numbers, lettering and wording as indicated and approved by the Owner/Engineer for proper identification and operation/maintenance of mechanical systems and equipment.

B. Multiple Systems: Where multiple systems of same generic name are shown and specified, provide identification which indicates individual system number as designated on the drawings or schedule as well as service.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS:

A. Coordination: Where identification is to be applied to surfaces which require insulation, painting or other covering or finish including valve tags in finished mechanical spaces, install identification after completion of covering and painting. Install identification prior to installation of acoustical ceilings and similar removable concealment.

3.2 PIPING SYSTEM IDENTIFICATION:
A. General: Install pipe markers of the following type on each system indicated to receive identification, and include arrows to show normal direction of flow. Existing building identification shall match the existing method which exists in the building.

B. Plastic pipe markers, with application system as indicated under "Materials" in this section. Install on pipe insulation segment where required for hot non-insulated pipes.

C. Locate pipe markers and color bands as follows wherever piping is exposed to view in occupied spaces, machine rooms, accessible maintenance spaces (shafts, tunnels, plenums) and exterior non-concealed locations.

D. Near each valve and control device.

E. Near each branch, excluding short take-offs for fixtures and terminal units; mark each pipe at branch, where there could be question of flow pattern.

F. Near locations where pipes pass through walls or floors/ceilings, or enter non-accessible enclosures.

G. At access doors, manholes and similar access points which permit view of concealed piping.

H. Near major equipment items and other points of origination and termination.

I. Spaced intermittently at maximum spacing of 25 feet along each piping run, except reduce spacing to 15’ in congested areas of piping and equipment.

J. On piping above removable acoustical ceilings.

K. Legend on steam piping, condensate return, compressed air, gas and vacuum system shall include working pressure or vacuum.

3.3 UNDERGROUND PIPING IDENTIFICATION:

A. General: During back-filling/top-soiling of each exterior underground piping systems, install continuous underground-type plastic line marker, located directly over buried line at 6 inches to 8 inches below finished grade. Where multiple small lines are buried in common trench and do not exceed overall width of 16 inches, install single line marker. For tile fields and similar installations, mark only edge pipe lines of field.

3.4 VALVE IDENTIFICATION:

A. Mount valve schedule frames and schedules in mechanical equipment rooms where directed by Architect/Owner/Engineer.

B. Where more than one major mechanical equipment room is shown for project, install mounted valve schedule in each major mechanical equipment room, and repeat only main valves which are to be operated in conjunction with operations of more than single mechanical equipment room.

3.5 MECHANICAL EQUIPMENT IDENTIFICATION:

A. UCB will provide Famis numbers and labels for the contractor to install. A spreadsheet will also be provided for the contractor to fill out.
B. General: Install minimum 2 inch x 4 inch engraved plastic laminate equipment marker on each individual items of mechanical equipment. Provide marker for the following general categories of equipment.

1. Main building systems control and operating valves, including safety devices and hazardous units such as gas outlets.
2. Fuel-burning units including boilers, furnaces, heaters, stills and absorption chillers.
3. Pumps, compressors, chillers, condensers and similar motor-driven units. Labels of Remote Equipment shall also indicate the space(s) being served and the location of their electrical breaker (panel ID, room no. and circuit).
   a. Identify pumps with service and zones served.
   b. Label refrigeration equipment with type and approximate quantity of refrigerant.
4. Heat exchangers, cooling towers, heat recovery units and similar equipment.
5. Fans and blowers.
6. Air terminal units.
7. Heaters, tanks and pressure vessels stencil as to service. Label connecting pipes and indicate entering and leaving temperatures.
8. Water treatment systems and similar equipment.
9. Controls – Nameplate or Stencil:
   a. Magnetic starters and relays
   b. Manual overload switches-indicate “connected” or “controlled” equipment.
   c. Automatic controls, control panels, p.e switches, e/p switches, relays and starters.
   d. Identify locations of control transformers on as-built drawings. Install labels on ceiling grid designating “CTRL XFMR”. Add tag at transformer indicating the device it serves.

C. Lettering Size: Minimum 1/4 inch high lettering for name of unit.

D. Text of Signs: In addition to the identified unit, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.

3.6 LIFT-OUT CEILINGS & ACCESS DOORS:

A. Provide Kroy type adhesive labels on ceiling tee or acess door to identify concealed valves, air terminal units, fire/smoke and fire dampers, or similar concealed mechanical equipment which is directly above nameplate in ceiling space. Labels shall be black lettering on white background.

B. Use the following colors for specified labels:

1. Fire –protection devices, including dampers: 3/8” red letters on white background
2. Isolation, balancing and control valves: 3/8” black letters on white background.
3. Isolation valves for plumbing: 3/8” blue letters on white background.

C. Label shall be installed oriented to read towards the ceiling tile that needs to be removed for access.

3.7 MOTORS CONTROLLED BY ENERGY MANAGEMENT SYSTEM:

A. The University shall furnish the following self-adhering signs which the Contractor shall install as indicated:

CAUTION

THIS EQUIPMENT IS UNDER COMPUTER CONTROL AND MAY CYCLE AT ANY TIME
BEFORE WORKING ON IT, DISCONNECT THE ELECTRICAL POWER AND CONTACT THE UNIVERSITY SERVICE CENTER AT EXT. 2-5522.

3.8 ADJUSTING AND CLEANING:

A. Adjusting: Relocate any mechanical identification device which has become visually blocked by work of this division or other divisions.

B. Cleaning: Clean face of identification devices, and glass frames of valve charts.

END OF SECTION 22 05 53
PART 1 - GENERAL

1.1 QUALITY ASSURANCE:

A. Insulation shall meet the more strict requirements of the latest versions of the International Energy Conservation Code and ASHRAE 90.1.

B. Manufacturer's Qualifications: Firms regularly engaged in manufacture of mechanical insulation products and systems, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 3 years.

C. Installer's Qualifications: Firm with at least 5 years successful installation experience on projects with mechanical insulations similar to that required for this project.

D. Flame/Smoke Ratings: Provide composite mechanical insulation (insulation, jackets, coverings, sealers, mastics and adhesives) with flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E 84 (NFPA 255) method. In addition, the products, when tested, shall not drip flame particles, and flame shall not be progressive. Provide Underwriters Laboratories Inc., label or listing, or satisfactory certified test report from an approved testing laboratory to prove that fire hazard ratings for materials proposed for use do not exceed those specified.

E. Insulation Materials: Non-combustible as defined in NFPA Pamphlet 220 and UL listed or labeled.

1.2 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data and installation instructions for each type of mechanical insulation. Submit schedule showing manufacturer's product number, k-value, thickness, density, and furnished accessories for each mechanical system requiring insulation. Submit detail product information and installation information for all jacketing systems specified in this section.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Manufacturer: Subject to compliance with requirements, provide product by one of the following:

   1. Mechanical Insulation:
      a. Armaflex
      b. Johns Manville Corp.
      c. Owens-Corning Fiberglas Corp.
      d. Knauf Fiber Glass
      e. Manson
f. Armstrong World Industries, Inc.
g. Nomaco

2. Jacketing & Covering Products:
a. Childers
b. Ceel-Co
c. Zeston
d. Alpha Associates, Inc.

2.2 PIPING INSULATION MATERIALS:

A. Fiberglass Piping Insulation: ASTM C 547, Class 1 unless otherwise indicated. "K" factor shall be maximum 0.24 at 75 degrees F. mean temperature, jacket with tensile strength of 35 lbs/in, mullen burst 70 psi, beach puncture 50 oz. in/in, permeability .02 perm factory applied vapor barrier jacket and adhesive self-sealing lap joint.

B. Cellular Glass Piping Insulation: ASTM C 552, Type II, Class 2. "K" factor shall be maximum 0.29 at 75 degrees F mean temperature.

C. Calcium Silicate Piping Insulation: ASTM C 533, Type I. "K" factor shall be maximum 0.45 at 500 degrees F. mean temperature, compression strength 200 psi for 5 percent compression, transverse strength 200 psi for 5 percent compression, flexural strength 60 psi.

D. Flexible Closed Cell Piping Insulation: ASTM C 534, Type I. "K" factor shall be maximum 0.27 at 75 degrees F. mean temperature, with a water vapor permeability of 0.10 perm inches or less. Insulation shall be pre-installed on piping, or un-slit to be slipped over piping as a single piece.

E. Flexible Thermal Ceramic Insulation [Fiber Retractory, Ceramic Fiber]: "K" factor shall be a maximum of 1.5 at 1500 degrees F mean temperature, 2000 degree F temperature limit. Provide presized glass cloth jacketing material, not less than 7.8 ounces per square yard, or metal jacket at Installer's option, unless otherwise indicated.

F. Rigid Thermal Ceramic Insulating System: "K" factor shall be a maximum of 1.5 at 1500 degrees F mean temperature, 2000 degrees F temperature limit.

G. Jackets for Piping Insulation: ASTM C 921, Type I for piping with temperatures below ambient, Type II for piping with temperatures above ambient. Type I may be used for all piping at Installers option.

1. Fitting Covers: UV resistant PVC, pre-molded fitting covers, flame spread 25, smoke developed 50. PVC tape for cold systems, serrated tacks or PVC tape for hot systems.

2. Aluminum Jacketing: Manufactured from T3003 (or T/5005) H14 to H19 aluminum alloy with 3/16" corrugations and shall have a factory attached 1 mil thick polyethylene moisture barrier continuously laminated across the full width of the jacketing. Jacketing shall be .016" thick minimum. Provide matching factory fabricated covers for 90 degrees and 45 degrees elbows, tee fittings, flange fittings valve bodies, blind ends, reducers and other fittings necessary to make the covering system complete, waterproof and weatherproof. All jacketing shall be color coated baked on polyester finish, color selected by Architect.

3. PVC Jacketing: UV resistant PVC, 30 mil thick, flame spread 25, smoke developed 50, factory cut and curled to fit O.D. of insulated pipe. Solvent weld adhesive for sealing joints and seams.
H. Staples, Bands, Wires, and Cement: As recommended by insulation manufacturer for applications indicated.

I. Adhesives, Sealers, and Protective Finishes: As recommended by insulation manufacturer for applications indicated and additional finishes as specified.

2.3 EQUIPMENT INSULATION MATERIALS:

A. Rigid Fiberglass Equipment Insulation: ASTM C 612, Class 2. "K" factor shall be maximum 0.28 at 200 degrees F. mean temperature, 3.0 lb. density, 850 degrees F temperature limit.

B. Flexible Fiberglass Equipment Insulation: ASTM C 553, Type I, "K" factor shall be maximum 0.45 at 250 degrees F. mean temperature. 850 degrees F temperature limit.

C. Calcium Silicate Equipment Insulation: ASTM C 533, Type I, Block. "K" factor shall be maximum 0.87 at 1000 degrees F. mean temperature, compression strength 200 psi for 5 percent compression, transverse strength 60 psi.

D. Flexible closed cell elastomeric insulation: ASTM C534, Type I, "K" valve shall be a maximum of 0.27 at 75 degrees F mean temp, 220 degrees F temperature limit, water vapor permeability of 0.10 perm inches or less.

E. Jacketing Material for Equipment Insulation: Provide pre-sized glass cloth jacketing material, not less than 7.8 ounces per square yard, or metal jacket at Installer's option, except as otherwise indicated.

F. Equipment Insulation Compounds: Provide adhesives, cements, sealers, mastics and protective finishes as recommended by insulation manufacturer for applications indicated.

G. Equipment Insulation Accessories: Provide staples, bands, wire, wire netting, tape, corner angles, anchors and stud pins as recommended by insulation manufacturer for applications indicated.

PART 3 - EXECUTION

3.1 INSPECTION:

A. Examine areas and conditions under which mechanical insulation is to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

B. Workmanship shall be first class and of the highest quality, poor installation or bad appearance as determined by the engineer shall be due cause to reject the entire project in whole and retainage will be withheld until corrective action is completed to the engineer's satisfaction.

3.2 PLUMBING PIPING SYSTEM INSULATION:

A. Insulation Omitted: Omit insulation on chrome-plated exposed piping (except for handicapped fixtures), air chambers, unions, balance cocks, flow regulators, drain lines from water coolers, drainage piping located in crawl spaces or tunnels, fire protection piping, and pre-insulated equipment.

B. Cold Piping:

1. Application Requirements: Insulate the following cold plumbing piping systems:

   a. Potable and non-potable cold water piping.
   b. Potable chilled water piping.
c. Interior above-ground horizontal storm and overflow water piping including elbow up & down.
d. Roof drain and overflow bowls and roof drain leader to horizontal piping and first vertical fitting before dropping down the shaft.
e. Overflow roof drain bowls and overflow horizontal pipe including first vertical elbow down the shaft.

2. Insulate each piping system specified above with the following types and thicknesses of insulation:
   a. Above Ground Inside Building Fiberglass; ½ inch thickness.

C. Hot Piping:

1. Application Requirements: Insulate the following hot plumbing piping systems:
   a. Potable hot water and tempered piping.
   b. Potable hot water and tempered recirculating piping.

2. Insulate each piping system specified above with the following types and thicknesses of insulation:
   a. Fiberglass; 1 inch thick.
   b. Sound Insulation: Insulate as shown on drawings. Provide 2 inch flexible fiberglass/vinyl sound insulation. Install with foil tape at all seams. Provide plastic wire ties every 18 inches around piping to fully fasten insulation to piping. Obtain a copy of manufacturer’s installation requirements, keep copy on site, and follow all instructions.

3.3 EQUIPMENT INSULATION:

A. Cold Equipment (Below Ambient Temperature):

1. Application Requirements: Insulate the following cold equipment:
   a. Refrigeration equipment, including chillers, tanks and pumps, including any cold surfaces not factory insulated.
   b. Condensate pans under chilled equipment.
   c. Cold water storage tanks.
   d. Cold water pumps.

2. Insulate each item of equipment specified above with the following types and thicknesses of insulation:
   a. Rigid Fiberglass: 1 inch thick for surfaces above 35 degrees F (2 degrees C) and 1-1/2 inch thick for surfaces 35 degrees F (2 degrees C) and lower.
   b. Flexible Elastomeric Sheet: ¾ inch thickness for surface temperatures above 35 degrees F (2 degrees C), 1 inch thickness for surface temperatures below 35 degrees F (2 degrees C).

B. Hot Equipment (Above Ambient Temperature):

1. Application Requirements: Insulate the following hot equipment:
   a. Water heaters (not pre-insulated at factory)
   b. Heat exchangers
2. Insulate each item of equipment specified above with the following types and thicknesses of insulation:
   a. Fiberglass: 2 inch thick, except 3 inch thick for low-pressure boilers and steam-jacketed heat exchangers. Do not use for equipment above 450 degrees F (232 degrees C).
   b. Calcium Silicate: 3 inch thick, except 4 inch thick for diesel exhaust mufflers and 4-1/2 inches thick for low-pressure boilers and steam-jacketed heat exchangers.

3. Application Requirements: Insulate the following breechings and stacks:
   a. Breechings between heating equipment outlet and stack or chimney connection, except for double wall or factory insulated breechings.
   b. Stacks from bottom to top except for factory insulated stacks.

4. Insulate each breeching and stack specified above with the following types and thicknesses of insulation:
   a. Calcium Silicate: 4 inches thick (2 layers of 2 inch thickness).

3.4 INSTALLATION OF PIPING INSULATION:

A. General: Install insulation products in accordance with manufacturer's written instructions, and in accordance with recognized industry practices to ensure that insulation serves its intended purpose.

B. Install insulation on pipe systems subsequent to installation of heat tracing, testing, and acceptance of tests.

C. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with single cut piece to complete run. Do not use cut pieces or scraps abutting each other.

D. Clean and dry pipe surfaces prior to insulating. Butt insulation joints firmly together to ensure complete and tight fit over surfaces to be covered.

E. Maintain integrity of vapor-barrier jackets on cold pipe insulation, and protect to prevent puncture or other damage.
   1. Do not use staples or tacks on vapor barrier jackets.
   2. Seal vapor barrier penetrations with vapor barrier finish recommended by the manufacturer.
   3. Seal fitting covers with PVC tape.
   4. Cover all unions, check valves, and other in-line devices. Mark outer covering with indelible marker to identify item covered.

F. Neatly bevel and seal insulation at all exposed edges.

G. Cover valves, fittings and similar items in each piping system with equivalent thickness and composition of insulation as applied to adjoining pipe run. Install factory molded, precut or job fabricated units (at Installer's option) except where specific form or type is indicated.
H. Extend piping insulation without interruption through walls, floors and similar piping penetrations, except where otherwise indicated.

I. See equipment insulation for removable insulation on accessible piping components.

J. See Section 230529 for insulation inserts and shields. Butt pipe insulation against pipe hanger insulation inserts. For all piping apply wet coat of vapor barrier lap cement on butt joints and seal all joints and seams with 3 inch wide vapor barrier tape or band.

K. Flexible Elastomeric Piping Insulation:
   1. Install unslit, by slipping over piping prior to joining, or install pre-insulated soft copper tubing.
   2. Seal butt ends with adhesive.

L. Cellular Glass Insulation:
   1. Apply in a single layer. Secure to pipe with ½ inch wide aluminum bands.
   2. For indoor applications, apply all purpose Kraft paper/aluminum foil/vinyl coating jacket. Seal all lap and butt joints with self seal vapor barrier tape.
   3. For outdoor applications, apply aluminum rubber/Tedlar jacketing as described below.

M. Calcium Silicate Insulation:
   1. Apply in a single layer. Secure to pipe with 1/2 inch wide aluminum bands.
   2. For indoor applications, provide canvas jacketing. Adhere joints of jacketing and provide a finish coat of sealant as recommended by the manufacturer.

N. Piping Exposed to Weather: Protect outdoor insulation from weather by installing aluminum rubber.
   1. Jacketing shall be secured by 1/2 inch wide stainless steel bands located on 24 inch centers. All joints and seams shall be caulked with clear silicone. Locate all longitudinal seams at the bottom of piping to minimize joint exposure to weather. Contractor may propose pre-fabricated sealing and fastening systems, submit samples and product data for approval.

3.5 INSTALLATION OF EQUIPMENT INSULATION:

A. General: Install equipment thermal insulation products in accordance with manufacturer's written instructions, and in compliance with recognized industry practices to ensure that insulation serves intended purpose. Complete finishes as specified.

B. Install insulation materials with smooth and even surfaces and on clean and dry surfaces. Redo poorly fitted joints. Do not use mastic or joint sealer as filler for gaping joints and excessive voids resulting from poor workmanship.

C. Maintain integrity of vapor-barrier on equipment insulation and protect it to prevent puncture and other damage.

D. Do not apply insulation to equipment, mufflers, breechings, or stacks while hot.
E. Apply insulation using staggered joint method and double layer construction. Apply each layer of insulation separately.

F. Insulation board shall be cut and mitered to fit the contour of the vessel and shall be applied with edges tightly butted, joints staggered where two or more layers are necessary (due to available thickness of insulation) and secured with 1/2 inch x 0.015 inch galvanized steel bands on 12 inch centers or with weld pins or stick clips with washers on 18 inch centers.

G. Coat insulated surfaces with layer of insulating cement, cover the insulation, 1 inch galvanized wire mesh shall be tightly stretched in place with edges tied together and finished between two coats of insulating cement troweled to a hard finish (not less than 1/4 inch thick).

H. Do not insulate hot equipment ASME stamp and manufacturer's nameplate. Provide neatly beveled edge at interruptions of insulation.

I. Cold equipment requiring access: Provide removable section of insulation, fabricated from flexible elastomeric insulation, adhered to an aluminum jacket, and joined with velcro strips around entire perimeter. Reinforce removable section and adjoining insulation at attachment points. Removable insulation shall be provided for all equipment requiring periodic inspection, access or maintenance including:

1. Chilled water pump bodies.
2. Strainer basket access.
3. Heat exchanger (including chillers) tube access.

J. Hot equipment requiring access: Provide Teflon-coated, Velcro closure, removable insulation jacket.

Provide removable insulation for hot equipment requiring access with accessible components over 100 square inches or any component operating over 200 degrees including:

K. Equipment Exposed to Weather: Protect outdoor insulation from weather by installation of aluminum jacketing, as recommended by manufacturer. On flexible elastomeric insulation, apply two (2) coats of manufacturer's approved U.V. resistant finish.

3.6 EXISTING INSULATION REPAIR:

A. Repair damaged sections of existing mechanical insulation, both previously damaged or damaged during this construction period. Use insulation, install new jacket lapping and sealed over existing.

3.7 PROTECTION AND REPLACEMENT:

A. Replace damaged insulation which cannot be repaired satisfactorily, including units with vapor barrier damage and moisture saturated units.

B. Protection: Insulation Installer shall advise Contractor of required protection for insulation work during remainder of construction period, to avoid damage and deterioration.

END OF SECTION 22 07 00
SECTION 22 11 16
BASIC PIPING MATERIALS AND METHODS

PART 1 - GENERAL

1.1 SUBMITTALS:

A. Refer to Division 1 and Basic Mechanical Requirements for administrative and procedural requirements for submittals.

B. Product Data: Submit industry standards and manufacturer's technical product data, installation instructions, and dimensioned drawings for each type of pipe and pipe fitting. Submit piping schedule showing pipe or tube weight, fitting type, and joint type for each piping system.

C. Welding Certifications: Submit reports as required for piping work.

D. Brazing Certifications: Submit reports as required for piping work.

1.2 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacturer of pipes and pipe fittings of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Welder's Qualifications: All welders shall be qualified in accordance with ASME Boiler and Pressure Vessel Code, Section IX, Welding and Brazing Qualifications.

C. Welding procedures and testing shall comply with the latest revisions of the applicable sections for B31, of the ANSI/ASME standard codes for pressure piping, noted as follows: B31.2 - Fuel Gas Piping Code.

D. Before any welding is performed, the contractor shall submit to the Architect, a copy of the Manufacturer's Record of Welder or Welding Operator Qualification Tests and his Welding Procedure Specification together with the Procedure Qualification Record as required by ASME Boiler and Pressure Vessel Code.

E. Each manufacturer or contractor shall be responsible for the quality of welding done by his organization and shall repair or replace any work not in accordance with these specifications.

F. Soldering and Brazing procedures shall conform to ANSI Standard Safety Code for Mechanical Refrigeration.

G. The University requires all plumbing work be performed under the direct supervision of licensed plumbers (4-year), with a ratio of not more than two apprentices per journeyman. The requirement also applies to licensed pipe fitters. Steam fitters need a City and County of Denver Journeyman Steam Fitters certification.

PART 2 PRODUCTS

2.1 GENERAL:

A. Piping Materials: Provide pipe and tube of type, pressure and temperature ratings, capacities, joint type, grade, size and weight (wall thickness or Class) indicated for each service. Where type, grade or class is
not indicated, provide proper selection as determined by Installer for installation requirements, and comply with governing regulations and industry standards.

B. Pipe/Tube Fittings: Provide factory-fabricated fittings of type, materials, grade, class and pressure rating indicated for each service and pipe size. Provide sizes and types matching pipe, tube, valve or equipment connection in each case. Where not otherwise indicated, comply with governing regulations and industry standards for selections, and with pipe manufacturer's recommendations where applicable.

2.2 COPPER TUBE AND FITTINGS:

A. Copper Tube: ASTM B 88; Type K or L as indicated for each service; hard-drawn temper, except as otherwise indicated.

B. ACR Copper Tube: ASTM B 280.


D. Wrought-Copper Solder-Joint Fittings: ANSI B16.22.

E. Cast-Copper Solder-Joint Drainage Fittings: ANSI B16.23 (drainage and vent with DWV or tube).

F. Wrought-Copper Solder-Joint Drainage Fittings: ANSI B16.29.


H. Bronze Pipe Flanges/Fittings: ANSI B16.24 (Class 150 and 300).

I. Copper-Tube Unions: Provide standard products recommended by manufacturer for use in service indicated.

2.3 CAST-IRON SOIL PIPES AND PIPE FITTINGS:

A. Hubless Cast-Iron Soil Pipe: FS WW-P-401 and CISPI Standards 301 and 310. Pipe and fittings shall be marked with the collective trademark of the cast iron soil pipe institute or receive prior approval of the engineer.

B. Cast-Iron Hub-and-Spigot Soil Pipe: ASTM A 74. Pipe and fittings shall be marked with the collective trademark of the cast iron soil pipe institute or receive prior approval of the engineer.


D. Heavy Duty Hubless Cast Iron Soil Pipe Couplings: Neoprene gasket coupling with ASTM C564. 304 stainless steel shield, minimum 0.15 inches thick, minimum 3 inches wide with 4 sealing bands up to 4 inch pipe, minimum 9 inches wide with 6 sealing bands up to 10 inch pipe.

1. Basis of Design: Husky SD 4000.


F. Neoprene Compression Gaskets: ASTM C 564.

2.4 MISCELLANEOUS PIPING MATERIALS/PRODUCTS:
A. Soldering Materials: All soldering materials shall be lead free and antimony-free.
   1. Melting Range 450-470 degrees F. All-state “Aquasafe” or equal.
   3. Flux: All flux shall be lead free, water soluble, and compatible with the solder and the materials being joined. ASTM B813-93.

B. Brazing Materials: Except as otherwise indicated, provide brazing materials to comply with installation requirements.
   1. Comply with AWSA 5.8, Section II, ASME Boiler and Pressure Vessel Code for brazing filler metal materials.
      a. Copper phosphorus -Bcup-5, 15 percent solver content, melting range 1190 to 1480 degrees F.
      b. Silver - BAg-36, 45 percent silver, cadmium-free. Melting range 1195 to 1265 degrees F.

C. Gaskets for Flanged Joints: ANSI B16.21; full-faced for cast-iron flanges; raised-face for steel flanges, unless otherwise indicated.

D. Piping Connectors for Dissimilar Non-Pressure Pipe: Elastomeric annular ring insert, or elastomeric flexible coupling secured at each end with stainless steel clamps, sized for exact fit to pipe ends and subject to approval by plumbing code.
   1. Manufacturer: Subject to compliance with requirements, provide piping connectors of the following:
      a. Husky Technologies (Husky SD 4000):

E. Pipe Thread Sealant Material: Except as otherwise indicated, provide all pipe threads with the sealant material as recommended by the manufacturer for the service.
   1. Manufacturer: Subject to compliance with requirements, provide piping thread sealant material of the following:
      a. The Rectorseal Corporation

F. Acid Resistant Drain Waste and Vent: (For use between fume hood and dilution basin)
   1. Polypropylene:
      a. Manufacturers:
         1) Enfield
         2) Orion
   2. Mechanical joints are required throughout the piping system.

PART 3 EXECUTION

3.1 EXAMINATION:
A. Verify all dimensions by field measurements. Verify that all water distribution piping may be installed in accordance with pertinent codes and regulations, and original design, and the referenced standards.

B. Examine rough-in requirements for plumbing fixtures and other equipment having water connections to verify actual locations of piping connections prior to installation.

C. Do not proceed until unsatisfactory conditions have been corrected.

3.2 PIPING INSTALLATION:

A. General: Install pipes and pipe fittings in accordance with recognized industry practices which will achieve permanently-leakproof piping systems, capable of performing each indicated service without piping failure. Install each run with minimum joints and couplings, but with adequate and accessible unions for disassembly and maintenance/replacement of valves and equipment. Reduce sizes (where indicated) by use of reducing fittings. Align piping accurately at connections, within 1/16 inch misalignment tolerance.

1. Comply with ANSI B31 Code for Pressure Piping.

2. Electrical Equipment Spaces: Do not run piping through transformer vaults and other electrical or electronic equipment spaces and enclosures. Only piping serving this type of equipment space shall be allowed.

3. Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate the general location and arrangement of piping systems. Locations and arrangements of piping take into consideration pipe sizing and friction loss, expansion, pump sizing, and other design considerations. So far as practical, install piping as indicated.

4. Use fittings for all changes in direction and all branch connections.

5. Install piping at right angles or parallel to building walls. Diagonal runs are not permitted, unless expressly indicated.

6. Conceal all pipe installations in walls, pipe chases, utility spaces, above ceilings, below grade or floors, unless indicated to be exposed to view.

7. Install piping tight to slabs, beams, joists, columns, walls, and other permanent elements of the building. Provide space to permit insulation applications, with 1 inch clearance outside the insulation. Allow sufficient space above removable ceiling panels to allow for panel removal.

8. Locate groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

9. Install drains in pressure pipe systems at all low points in mains, risers, and branch lines consisting of a tee fitting, ¾ inch ball valve, and short ¾ inch threaded end nipple and cap with chain.

10. Install piping free of sags or bends and with ample space between piping to permit proper insulation applications.

11. Fire and Smoke Wall Penetrations: Where pipes pass through fire and smoke rated walls, partitions, ceilings, and floors, maintain the fire and smoke rated integrity. Refer to Division 15, Section 15120 and 15050 for materials.
12. **Exterior Wall Penetrations:** Seal pipe penetrations through exterior walls using sleeves and mechanical sleeve seals (See Section 15120). Pipe sleeves smaller than 6 inch shall be steel; pipe sleeves 6 inches and larger shall be sheet metal.

13. **Floor Penetrations:**
   a. Install sleeves 2” A.F.F. for all penetrations in rooms with floor drains and for all penetrations in walls surrounding the rooms.
   b. Kitchens and Mechanical Rooms – extend 4” A.F.F.
   c. All other areas where piping is exposed, extend ¼” A.F.F.
   d. All existing floors that are core drilled shall comply with a, b and c of this section.

14. Anchor piping to ensure proper direction of expansion and contraction.

15. Coordinate foundation and all other structural penetrations with structural engineer.

16. All underground piping shall be surrounded by 6” of squeegee.

17. All copper piping 1-1/2” and smaller to be soldered; all piping 2” and larger to be braced.

B. **Sanitary Waste and Vent; Roof Drain and Storm Drain Piping:**

1. Install plumbing drainage piping with 1/4 inch per foot (2 percent) downward slope in direction of drain for piping 3 inches and smaller, and 1/8 inch per foot (1 percent) for piping 4 inch and larger. Install cast iron pipe in accordance with the Cast Iron Soil Pipe Institute Handbook.

2. Install 1 inch thick extruded polystyrene over underground drainage piping that is above frost line and not under building. Provide width to extend minimum of 12 inches beyond each side of pipe. Install directly over pipe, centered on pipe center line.

3. Make changes in direction for drainage and vent piping using appropriate 45 degree wyes, half-wyes, or long sweep quarter, sixth, eighth, or sixteenth bends. **SANITARY CROSSES OR SHORT QUARTER BENDS SHALL NOT BE USED IN DRAIN PIPING.**

4. Provide thrust restraints (bracing to structure or rodded joints) at branches and changes in direction for cast iron pipe 5 inches and larger suspended within the building.

5. Where cast iron piping is suspended in excess of 18 inches on single rod hangers, sway bracing shall be provided to prevent shear at the joints.

6. Install underground drain piping to conform with the plumbing code, and in accordance with the Cast Iron Soil Pipe Institute Engineering Manual.

7. Lay piping beginning at low point of system, true to grades and alignment indicated, with unbroken continuity of invert.

8. Place bell ends or groove ends of piping facing upstream.

9. Install gaskets in accordance with manufacturer's recommendations for use of lubricants, cements, and other special installation requirements.
10. Install sub-surface drain piping according to requirements of the soils engineers requirements when required and connect to storm sewer / sump pump.

11. Grade trench bottoms to provide a smooth, firm, and stable foundation, free from rock, throughout the length of the pipe.

12. Remove unstable, soft, and unsuitable materials at the surface upon which pipes shall be laid, and backfill with squeegee to indicated invert elevation.

13. Shape bottom of trench to fit the bottom 1/4 of the circumference of pipe. Fill unevenness with squeegee. At each pipe joint dig bell holes to relieve the bell of the pipe of all loads, and to ensure continuous bearing of the pipe barrel on the foundation.

C. Condensate Drain Piping:

1. Condensate drain piping from air conditioning unit coil condensate drain pan shall be of the sizes shown on the drawings.

D. Plastic Pipe:

1. All plastic piping installed below grade shall meet ASTM D2321-89 requirements.

3.3 PIPING SYSTEM JOINTS:

A. General: Provide joints of type indicated in each piping system.

B. Thread pipe in accordance with ANSI B2.1; cut threads full and clean using sharp dies. Ream threaded ends to remove burrs and restore full inside diameter. Apply pipe joint compound, or pipe joint tape (Teflon) where recommended by pipe/fitting manufacturer, on male threads at each joint and tighten joint to leave not more than 3 threads exposed.

C. Copper ≥ 2": Braze copper tube-and-fitting joints in accordance with ASME B31.

D. Copper < 2": Solder copper tube-and-fitting joints with silver solder. Cut tube ends squarely, ream to full inside diameter, and clean outside of tube ends and inside of fittings. Apply solder flux to joint areas of both tubes and fittings. Insert tube full depth into fitting, and solder in manner which will draw solder full depth and circumference of joint. Wipe excess solder from joint before it hardens.

E. Flanged Joints: Match flanges within piping system, and at connections with valves and equipment. Clean flange faces and install gaskets. Tighten bolts to provide uniform compression of gaskets.

F. Hubless Cast-Iron Joints: Comply with coupling manufacturer's installation instructions. Use pre-set torque wrench set to 80 in-lbs on heavy duty couplings.

3.4 PIPING APPLICATION:

A. Domestic Hot and Cold Water - Inside Building:

1. Above Grade Inside Building:

   a. 1-1/2" inches and Smaller: Type K, hard drawn copper tube with wrought copper or bronze fittings, lead/antinomy free soldered joints.
b. 2” and Larger: Type K, hard drawn copper tube with wrought copper or bronze fittings, brazed joints.

c. Provide plastic isolators at all clamps.

2. Below Grade Inside and Outside Building:

a. 1-1/2 inches and Smaller: Type K, soft copper or Type K annealed copper tube with wrought copper fittings, silver tin alloy solder joints.

b. Larger than 1-1/2 inches: Ductile iron, tar coated outside, cement mortar lined inside. Full lengths of pipe shall be utilized to the greatest extent possible. Fittings for ductile iron pipe shall be 350 psi pressure, tar coated outside and cement lined inside. Rubber gasket joints. Surround with 6” of squeegee.

B. Sanitary Drainage and Vents - Inside Building:

1. Above Grade: Service weight cast iron, no-hub type with neoprene gaskets; service weight cast iron, hub and spigot type with neoprene gaskets; or type L copper.

   a. Provide husky series 4000 couplings for waste pipe above critical spaces including:

   1) Food Service
   2) NMR Rooms
   3) Mass Spectrometry Rooms

2. Below Grade: Sizes 2 inch to 20 inch, service weight cast iron, hub and spigot type only with neoprene compression gaskets; or sizes 12 inches and larger ductile cast iron with neoprene gasket joints with Husky Series 4000 couplings or equivalent.

3. Electrical & Communications rooms where pipes cannot avoid routing above.

C. Sanitary Sewer - Beyond 5 feet Outside Building: Refer to Civil.

D. Roof Drainage - Inside Building:

1. Above Grade:

   a. 30 foot head or less: Service weight cast iron, hub and spigot type or no-hub Husky Series 4000 (or equivalent); or galvanized steel with galvanized cast iron drainage fittings and threaded joints.

   b. Over 30 foot head: Schedule 40 galvanized steel pipe with galvanized cast iron drainage fittings and threaded joints; or schedule 40 grooved galvanized steel pipe joined with rigid couplings and gaskets designed for water service, molded of materials conforming to ASTM D-2000; or ductile iron, thickness 52 or ANSI/AWWA C150/A21.50-81, 350 psi pressure rating. Full lengths of pipe shall be utilized to greatest extent possible.

2. Below Grade: Sizes 2 inch to 20 inch, service weight cast iron, hub and spigot type or sizes 12 inches and larger ductile cast iron with neoprene gasket joints with Husky Series 4000 couplings or equivalent.

E. Storm Sewer - Beyond 5 feet Outside Building: Refer to Civil.
F. Accessible Gas Piping:

1. Above Grade:
   a. Exposed Location:
      1) All Sizes: Schedule 40 black steel with butt weld fittings and welded joints.
      2) Above Ground Outside: Schedule 40 black steel pipe sizes matching above. Piping shall be painted to protect against rust.
   b. Inaccessible Location:
      1) All sizes: Schedule 40 black steel pipe, beveled ends, with socket or butt weld fittings same thickness as pipe; welded joints.

2. Below Grade: Schedule 40 seamless black steel with 150 lb. forged steel fittings and welded joints. Provide machine applied, coated and wrapped pipe in accordance with local code and utility company requirements. Provide cathodic protection.

G. Equipment Drains and Overflows:

1. Type "L" or copper.

H. Sump Pump Discharge:

1. Type L, seamless, hard drawn copper tube with ANSI/ASME B16.22 wrought copper or bronze solder-joint pressure fittings.

3.5 EXPOSED PIPING IN FINISHED AREAS:

A. Plumbing piping and fittings which are exposed (and uninsulated) in finished areas generally occupied by people including, but not limited to, kitchens, animal cagewash/equipment washing rooms, autoclave or sterilizing rooms shall be installed with a smooth, high polish, durable chrome plated finish.

3.6 PIPING TESTS:

A. General: Provide temporary equipment for testing, including pump and gauges. Test piping system before insulation is installed wherever feasible, and remove control devices before testing. Test each section of each piping system independently but do not use piping system valves to isolate sections where test pressure exceeds valve pressure rating. Fill each section with water and pressurize for indicated pressure and time.

B. Test all piping systems as specified. Correct leaks by remaking joints. Remove equipment not able to withstand test procedure during test.

C. Work to be installed shall remain uncovered until the required tests have been completed.

D. Piping which is to be concealed shall be tested before being permanently enclosed.

E. As soon as work has been completed, conduct preliminary tests to ascertain compliance with specified requirements. Make repairs or replacements as required.
F. Give a minimum of twenty-four hours notice to Engineer of dates when acceptance test will be conducted. Conduct tests as specified for each system in presence of representative of owner, agency having jurisdiction or his representative. Submit three (3) copies of successful tests to the Engineer for his review. Report shall state system tested and date of successful test.

G. Contractor shall obtain certificates of approval, acceptance and compliance with regulations of agencies having jurisdiction. Work shall not be considered complete until such certificates have been delivered by the Engineer to the Owner.

H. All costs involved in these tests shall be borne by Contractor.

I. System Tests

1. Hydrostatic Test: The test shall be accomplished by hand pumping the system to the specified water pressure, and maintaining that pressure until the entire system has been inspected for leaks, but in no case for a time period of less than four hours.
   a. Domestic water systems: 100 psig or 150 percent of system pressure, whichever is greater.

2. Compressed Air or Nitrogen Test: Compressed air tests may be substituted for hydrostatic tests only when ambient conditions prohibit safe use of hydrostatic testing and must be reviewed by the Engineer prior to any testing. For tests of this type, the piping system shall be subjected to the gas pressure indicated for that specific system. The piping capped or plugged and water-pumped with oil free air, or a nitrogen bottle shall be introduced into the entire system to the pressure specified. The system shall maintain that pressure for the duration of a soapy water test of each joint.

3. Waste, Drain and Vent Piping: All waste and vent piping, including building drain, roof drain and building sewer, shall be subjected to a water test. All openings in the piping system shall be tightly closed, except the highest opening, and the system filled with water to the point of overflow. The water shall be kept in the system, or in the portion under test, for at least 15 minutes before inspection starts; the system shall then be tight to all points. No section shall be tested with less than a ten foot head of water. Roof drain shall be closed at the lowest point and filled with water to the point of overflow.

4. Sump Pump Discharge: With water in sump and pump running at full capacity, check for leaks until satisfied that system is tight.

5. Repair piping systems sections which fail required piping test, by disassembly and re-installation, using new materials to extent required to overcome leakage. Do not use chemicals, stop-leak compounds, mastics, or other temporary repair methods.

6. Drain test water from piping systems after testing and repair work has been completed.

3.7 UNDERGROUND PIPE INSTALLATION:

A. Clean fittings, nipples and other field joints thoroughly before coating.

B. Protect gray and ductile cast iron pipe installed below grade with polyethylene encasement applied in strict accordance with ANSI/AWWA C105/A21.5.

C. Install ductile iron pipe below grade as prescribed by AWWA C600.
D. Provide concrete thrust block and 3/4 inch steel threaded tie bar at each direction change on underground pressure pipe. Imbed tie bar in thrust block and connect to upstream fitting. Paint tie bar with two coats of bitumastic #50 paint.

E. Bury all outside water piping minimum 5 feet-0 inches below grade to top of pipe.

3.8 ADJUSTING AND CLEANING:

A. General: Clean exterior surfaces of installed piping systems of superfluous materials, and prepare for application of specified coatings (if any). Flush out piping systems with clean water before proceeding with required tests. Inspect each run of each system for completion of joints, supports and accessory items.

1. Inspect pressure piping in accordance with procedures of ASME B31.

B. Disinfect all potable water mains and water service piping in accordance with local and health department requirements. Submit test results report.

3.9 COMMISSIONING:

A. Fill system and perform initial chemical treatment.

B. Check expansion tanks to determine that they are not air bound and that the system is completely full of water.

C. Before operating the system perform these steps:

1. Open valves to full open position. Close coil bypass valves.
2. Remove and clean strainers.
3. Check pump for proper rotation and proper wiring.
4. Set automatic fill valves for required system pressure.
5. Check air vents at high points of systems and determine if all are installed and operating freely (automatic type) or to bleed air completely (manual type).
6. Set temperature controls so all coils are calling for full flow.
7. Check operation of automatic bypass valve.
8. Check and set operating temperature of boilers, chillers, and cooling towers to design requirements.
9. Lubricate motors and bearings.

END OF SECTION 22 11 16
SECTION 22 11 19
WATER DISTRIBUTION PIPING

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. This Section specifies the water distribution piping system, including potable cold, hot, and recirculated hot water piping, fittings, and specialties within the building to a point 5 feet outside the building.

B. Products installed but not furnished under this Section include water meters which will be provided by the utility company, to the site, ready for installation.

C. Related Sections: The following Sections contain requirements that relate to this section.

   1. Refer to Division 2 for below grade water service piping from public utility water main to building.

   2. Refer to Division 2 for trenching and backfilling materials and methods for underground piping installations.

   3. Refer to other Division 22 sections for piping materials; methods for sealing pipe penetrations through basement walls and fire and smoke barriers; thermometers, flow meters and pressure gauges; mechanical identification; plumbing pumps; and dielectric unions, strainers and pressure regulating valves.

1.2 DEFINITIONS:

A. Water Distribution Piping: A pipe within the building or on the premises which conveys water from the water service pipe or meter to the points of usage.

B. Water Service Piping: The pipe from the water main or other source of potable water supply to the water distributing system of the building served.

C. Pipe Sizes used in this Specification are Nominal Pipe Size (NPS).

1.3 SUBMITTALS:

A. Refer to Division 1 and Basic Mechanical Requirements for administrative and procedural requirements for submittals.

B. Provide data for each piping specialty and valve specified.

C. Certification of Compliance with ASME and UL fabrication requirements.

D. Test reports specified in Part 3 of this Section.

E. Manufacturer and product data for lead free solder with material breakdown.

F. Maintenance data for each piping specialty and valve specified for inclusion in operation and maintenance manual specified in Division 22.
1.4 QUALITY ASSURANCE:
   A. Regulatory Requirements: Comply with the provisions of the following:
      1. ASME B 31.9 "Building Services Piping" for materials, products and installation. Safety valves
         and pressure vessels shall bear the appropriate ASME label.
      2. ASME "Boiler and Pressure Vessel Code", Section IX, "Welding and Brazing Qualification" for
         Qualifications for Welding Processes and Operators.
      3. Local Plumbing Code and Utility Department requirements.
      4. Local cross connection control manual.

1.5 DELIVERY, STORAGE AND HANDLING:
   A. Store pipe in a manner to prevent sagging and bending.
   B. Cap ends of piping when being stored.

1.6 SEQUENCING AND SCHEDULING:
   A. Coordinate the size and location of concrete equipment pads. Cast anchor bolt inserts into pad.
      Concrete, reinforcement, and formwork requirements are specified in Division 3.
   B. Coordinate the installation of pipe sleeves for foundation wall penetrations.

1.7 EXTRA STOCK:
   A. Maintenance Stock: Furnish one valve key for each key operated wall hydrant, hose bibb, or faucet
      installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:
   A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1. Hose Bibbs and Faucets:
         a. Chicago Faucet Co.
         b. Woodford Mfr Co.
      2. Wall Hydrants:
      3. Hose Stations:
         a. Leonard
         b. T & S Brass
         c. Duco
      4. Backflow Preventers:
         a. Febco Sales, Inc.; Subs. of Charles M. Bailey Co., Inc.
5. Water Meters:
   a. Badger Meter, Inc.
   b. Hersey Products Inc.

6. Relief Valves:
   b. Watts Regulator Co.
   c. Conbraco Industries, Inc.
   d. Wilkins
   e. Kunkle

7. Shock Arresters - Bellows Type:
   a. Josam
   c. Wade
   d. Zurn

8. Water Tempering Valves
   a. Powers
   b. Leonard
   c. Rada

9. Pressure Reducing Valves: (Regulation)
   a. Watts Regulator Co.
   b. Mueller

10. Vacuum Breakers for Hose Connections:
    a. Watts Regulator Co.

11. Vacuum Breakers for Irrigation:
    a. Febco

12. Spill Resistant Vacuum (for evap. Coolers, cooling towers and fume hood clusters):

13. Domestic Hot Water Expansion Tanks
    a. Amtrol
    b. State Industries
    c. Taco

2.2 PIPE AND TUBE MATERIALS:

A. General: Provide pipe material and pipe fittings complying with Division 22.

2.3 BASIC SUPPORTS AND ANCHORS:
A. **General:** Provide supports and anchors complying with Division 22.

### 2.4 GENERAL DUTY VALVES:

A. **General:** Provide valves complying with Division 22.

### 2.5 SPECIAL DUTY VALVES:

A. Calibrated Balance Valve: Refer to Section 22 05 19.

### 2.6 PIPING SPECIALTIES:

A. **Shock Arresters - Bellows Type:** Stainless steel casing and bellows, rated for 250 psi, 200 degrees F, tested and certified in accordance with PDI Standard WH-201.

B. **Hose Bibbs** – Refer also to plumbing fixture schedule.

1. **HB - 1 Unfinished and Equipment Rooms:** Rough chrome plated bronze body, renewable composition disc, [tee] wheel handle, vacuum breaker, 3/4 inch NPT inlet, 3/4 inch hose outlet with vacuum breaker.

   Woodford No. 24 or Y24

2. **HB - 2 Finished Rooms with Floor Drains:** Polished chrome plated bronze body, with renewable composition disc, tee handle, 3/4 inch NPT inlet, 3/4 inch hose outlet.

   Chicago Faucet No. 952-293-6

C. **Wall Hydrants** – Refer also to plumbing fixture schedule

1. **WH-1 Exposed type non-freeze wall hydrant:** All brass with chrome plated face plate, "T" handle loose key, integral vacuum breaker, self draining body and shank, exposed 3/4 inch male hose thread outlet, 3/4 inch male or female thread inlet, renewable seat; shank length to extend thru primary exterior wall sufficient distance to prevent freezing.

   Woodford Model 67

2. **WH-2 Flush with wall, non-freeze, box type, wall hydrant:** All brass with nickel bronze box cover and frame, "T" handle loose key, key lock cover, integral vacuum breaker, self draining body and shank, ¾ inch male hose thread outlet, ¾ inch male or female I.P.S. thread inlet, renewable seat; shank length to extend thru primary exterior wall surface sufficient distance to prevent freezing.

   Woodford Model B67

D. **Hose Stations:**

1. **HS-1:** Provide hot and cold water mixing hose stations exposed, complete with hose, nozzle, hose rack, valves, vacuum breaker, and anchoring. Mixing unit and hose rack to be polished chrome.

   Leonard Model #SW-75-EVBD
   Hose Leonard Model 25HDH
   Nozzle Leonard Model N-2
E. Backflow Preventers:

1. BFP-1 (Vacuum Breaker, Atmospheric): Atmospheric type, all brass, angle pattern with disc float that closes the atmospheric vent for temperatures up to 210 degrees F.; full size orifice for maximum flow; female thread inlet and outlet; rough brass [chrome plated] exterior finish; unit to be approved by National Sanitary Foundation.
   a. Watts No. 288

2. BFP-2 (Vacuum Breaker Pressure Type): Spill resistant design, suitable for indoor or outdoor installation, with vent seal diaphragm designed to seal air vent prior to opening the check valve. Suitable for use with downstream valves. Provided with ball valve shut-offs and test cocks.
   a. Watts Series 008QT

3. BFP-3 (Double Check Assembly): Sizes 3/4inch through 2inches include two spring-loaded, Y-pattern bronze check valves, two bronze ball valves and four testcocks for field testing. All valves are threaded type and the unit is shipped completely assembled.
   Sizes 2-1/2inches through 10inches include two spring loaded Y-pattern check valves with epoxy coated ductile iron bodies and bronze trim, two cast iron non-rising stem/OS&Y gate valves and four testcocks for field testing. Compact style, inlet flow vertical up, outlet flow vertical down or up as shown on drawings. All valves are flanged type and the unit is shipped completely assembled; unit to be approved by National Sanitary Foundation, U.S.C. Foundation for Cross Connection Control, A.S.S.E. State and or Local authorities.
   a. Febco No. 805 through 2inch size, No. 850 2-1/2inches through 10inches
   b. Sizes 2inch through 10inch compact style - Febco Model 870/870V.

4. BFP-4 (Reduced pressure type): All bronze (3/4inch-2inch)/ductile iron (2-1/2inch – 10inches) body with two independently operating, spring loaded check valves and one differential relief valve with automatic intermediate atmospheric vent. Pressure in intermediate zone to activate relief valve when there is a 2 psig. differential between the zone and the upstream side of the first check valve. The relief valve shall remain open until a positive pressure differential is re-established. Assembly to be furnished with fullport, positive shut off non-rising stem, OS&Y isolation valves, in-line strainer, union connections, funnel, and all test cocks. Compact style, inlet flow vertical up, outlet flow vertical down or up. Assembly to have approval of National Sanitary Foundation, U.S.C. Foundation for Cross Connection Control, A.S.S.E. State and or Local Authorities.
   a. Febco No. 825Y through 2inch size; No. 860 2-1/2inch through 10inches
   b. Sizes 2-1/2inch through 10inch compact style - Febco Model 880/880V.
   c. Wilkins 975XL (if alarm required)

5. BFP-5 (Carbonated Water for Beverage Dispensing Equipment): Stainless steel body and parts, positive double check valve rated for 150 psi at 140 degrees F. Heavy duty rubber seats shall comply with FDA food additive regulations and ASSE 1013 and 1022.
   3/8inch - Watts Model No. SD-3 or equal.

F. Pressure Vacuum Breakers (for irrigation):

1. Febco 765
G. Spill-Resistant Vacuum Breakers:
   1. Watts 008PCQT

H. Pressure Reducing Valves (Direct Acting)
   1. Refer to water pressure reducing station detail for information.

2.7 WATER METER:
   A. Refer to plumbing fixture schedule. Provide materials and accessories consistent with the schedule make & model.

2.8 DOMESTIC HOT WATER EXPANSION TANKS:
   A. Refer to plumbing fixture schedule. Provide materials and accessories consistent with the schedule make & model.

PART 3 - EXECUTION

3.1 EXAMINATION
   A. Verify all dimensions by field measurements. Verify that all water distribution piping may be installed in accordance with pertinent codes and regulations, the original design, and the referenced standards.

   B. Examine rough-in requirements for plumbing fixtures and other equipment having water connections to verify actual locations of piping connections prior to installation.

   C. Do not proceed until unsatisfactory conditions have been corrected.

3.2 PIPING INSTALLATION:
   A. Refer to Section 22 11 16, "Basic Water Distribution Piping" for installation of piping.

   B. Install backflow preventers on plumbing lines where contamination of domestic water may occur and on boiler make-up lines, hose bibbs and flush valves.

   C. Install pressure reducing valves to limit maximum static pressure at plumbing fixtures to 75 psig.

   D. Install water hammer arresters in domestic water piping system on each set of flush valves and where hydrostatic shock pressures could occur.

   E. Yard hydrants to be installed as shown in detail on mechanical plans.

3.3 HANGERS AND SUPPORTS:
   A. Refer to Section 22 05 29, "Supports and Anchors" for supports and anchors.

3.4 PIPE AND TUBE JOINT CONSTRUCTION:
   A. Refer to Section 22 11 16, "Basic Water Distribution Piping" for pipe joints.

3.5 SERVICE ENTRANCE:
A. Extend water distribution piping to connect to water service piping, of size and in location indicated for service entrance to building. Water service piping is specified in a separate section of Division 2.

B. Install sleeve and mechanical sleeve seal at penetrations through foundation wall for watertight installation as detailed on mechanical drawings.

C. Install shutoff valve at service entrance inside building; complete with strainer, pressure gauge, and test tee with valve.

D. Ductile-Iron Pipe: Install in accordance with AWWA C-60.

E. Provide thrust blocks on underground water piping at each change in direction and where shown on the drawings.

F. Coordinate foundation and all other structural penetrations with structural engineer.

G. Submit layout of water entry for approval by UCB

3.6 INSTALLATION OF WATER METER:

A. Install water meter in accordance with utility company's installation instructions and requirements.

B. Set meter on concrete pad as indicated. Refer to Division 3 for concrete, formwork, and reinforcing requirements.

C. Mount meter on wall brackets as indicated.

D. Size meter and arrange piping and specialties to comply with utility company's requirements.

3.7 ROUGH-IN FOR WATER METER:

A. Install rough-in piping and specialties for water meter installation in accordance with utility company's instructions and requirements.

3.8 VALVE APPLICATIONS:

A. General Duty Valve Applications: The drawings indicate valve types to be used. Where specific valve types are not indicated the following requirements apply:

2. Throttling duty: Use ball, and butterfly valves.

3.9 INSTALLATION OF VALVES:

A. Sectional Valves: Install sectional valves on each branch and riser, close to main, where branch or riser serves 2 or more plumbing fixtures or equipment connections, and elsewhere as indicated. For sectional valves 2inch and smaller, use ball valves; for sectional valves 2- 1/2inch and larger, use gate or butterfly valves.

B. Shutoff Valves: Install shutoff valves on inlet of each plumbing equipment item, and on inlet of each plumbing fixture, and elsewhere as indicated. For shutoff valves 2inch and smaller, use ball valves; for shutoff valves 2- 1/2inch and larger, use butterfly valves.

C. Drain Valves: Install drain valves on each plumbing equipment item, located to completely drain equipment for service or repair. Install drain valves at the base of each riser, at low points of horizontal
runs, and elsewhere as required to completely drain distribution piping system. For drain valves 2inch and smaller, use ball valves; for drain valves 2-1/2inch and larger, use butterfly valves.

D. Check Valves: Install non-slam spring loaded check valves on discharge side of each pump, and elsewhere as indicated.

E. Balance Cocks: Install in each hot water recirculating loop, discharge side of each pump, and elsewhere as indicated.

F. Hose Bibbs: Install on exposed piping where indicated, with vacuum breaker.

G. Wall Hydrants: Install where indicated with vacuum breaker.

3.10 INSTALLATION OF PIPING SPECIALTIES:

A. Install backflow preventers at each connection to mechanical equipment and systems, and in compliance with the plumbing code and authority having jurisdiction. Locate in same room as equipment being connected. Pipe relief outlet thru air gap and without valves, to nearest floor drain.

B. Install pressure regulating valves with inlet and outlet shutoff valves, and balance cock bypass. Install pressure gauge on valve outlet.

C. Install shock arresters in locations shown on drawings and at all water connections to equipment with quick closing valves, including, but not limited to: dishwashers, disposals, clothes washers, ice makers, auto claves, pre-rinse spray hose, etc. Provide isolation valve. Install in accessible location as close to the quick-closing valve as possible. Provide access doors in accordance with architectural recommendations.

1. Units shall be sized in accordance with the following schedule.

<table>
<thead>
<tr>
<th>Drawing Designation</th>
<th>Fixture Unit Rating</th>
<th>P.D.I. Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>SA-1</td>
<td>1-11</td>
<td>A</td>
</tr>
<tr>
<td>SA-2</td>
<td>12-32</td>
<td>B</td>
</tr>
<tr>
<td>SA-3</td>
<td>33-60</td>
<td>C</td>
</tr>
<tr>
<td>SA-4</td>
<td>61-113</td>
<td>D</td>
</tr>
<tr>
<td>SA-5</td>
<td>114-154</td>
<td>E</td>
</tr>
<tr>
<td>SA-6</td>
<td>155-330</td>
<td>F</td>
</tr>
</tbody>
</table>

D. Install air vents at high points above lavatory of fixture groups.

3.11 INSTALLATION OF DOMESTIC HOT WATER EXPANSION TANKS:

A. Install expansion tanks in compliance with the plumbing code and the authority having jurisdiction.

B. Locate tanks in the same room as the water heaters on storage tanks on the cold water supply line as close to the water heater or storage tank as possible. Installation is to be between the water heater or storage tank and backflow preventer, check valve, pressure reducing valve and/or meter.
C. Provide independent support for in-line mounted tanks.

D. Precharge tank to minimum static water pressure at the tank location.

3.12 EQUIPMENT CONNECTIONS:

A. Piping Runouts to Fixtures: Provide hot and cold water piping runouts to fixtures of sizes indicated, but in no case smaller than required by Plumbing Code.

B. Mechanical Equipment Connections: Connect hot and cold water piping system to mechanical equipment as indicated. Provide shutoff valve and union for each connection, provide drain valve on drain connection. Provide back-flow preventor as shown as required. For connections 2-1/2 inch and larger, use flanges instead of unions.

3.13 FIELD QUALITY CONTROL:

A. Inspections: Inspect water distribution piping as follows:

1. Do not enclose, cover, or put into operation water distribution piping system until it has been inspected and approved by the authority having jurisdiction.

2. During the progress of the installation, notify the plumbing official having jurisdiction, at least 48 hours prior to the time such inspection must be made. Perform tests specified below in the presence of the plumbing official.

   a. Rough-in Inspection: Arrange for inspection of the piping system before concealed or closed-in after system is roughed-in, and prior to setting fixtures.

   b. Final Inspection: Arrange for a final inspection by the plumbing official to observe the tests specified below and to insure compliance with the requirements of the plumbing code.

3. Reinspections: Whenever the plumbing official finds that the piping system will not pass the test or inspection, make the required corrections and arrange for reinspection by the plumbing official.

4. Reports: Prepare inspection reports, signed by the plumbing official.

B. Test water distribution piping as follows:

1. Refer to Section 22 11 16 "Basic Piping Materials and Methods" for pipe test.

3.14 ADJUSTING AND CLEANING:

A. Clean and disinfect water distribution piping as follows:

1. Purge all new water distribution piping systems and parts of existing systems, which have been altered, extended, or repaired prior to use.

2. Use the purging and disinfecting procedure prescribed by the authority having jurisdiction, or in case a method is not prescribed by that authority, the procedure described in either AWWA C651, or AWWA C652, or as described below:

   a. Flush the piping system with clean, potable water until dirty water does not appear at the points of outlet.
b. Fill the system or part thereof, with a water/chlorine solution containing at least 50 parts per million of chlorine. Isolate (valve off) the system, or part thereof, and allow to stand for 24 hours.

c. Drain the system, or part thereof, of the previous solution, and refill with a water/chlorine solution containing at least 200 parts per million of chlorine and isolate and allow to stand for 3 hours.

d. Following the allowed standing time, flush the system with clean potable water until chlorine does not remain in the water coming for the system.

e. An independent contractor shall sample and submit water samples in sterile bottles to the authority having jurisdiction and commissioning agent. Repeat the procedure if the biological examination made by the authority shows evidence of contamination.

B. Prepare reports for all purging and disinfecting activities.

3.15 COMMISSIONING:

A. Fill the system.

B. Check compression tanks to determine that they are not air bound and that the system is completely full of water.

C. Before operating the system perform these steps:

1. Open valves to full open position. Close drain, valves, hydrants, and sill cocks.
2. Remove and clean strainers.
3. Check pump for proper direction of rotation. Correct improper wiring.
4. Lubricate pump motors and bearings.

END OF SECTION 22 11 19
SECTION 22 13 19
DRAINAGE AND VENT SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. This Section specifies building sanitary drainage, storm drainage and vent piping systems, including drains and drainage specialties.

B. Related Sections: The following sections contain requirements that relate to this section:

1. Refer to Division 2 sections for trenching and backfilling materials and methods for underground piping installations; not work of this section.

2. Refer to Division 2 Section for storm water drainage piping beginning from 5feet-0inches outside the building; sanitary drainage piping beginning from 5feet-0inches outside the building; foundation drain piping; not work of this section.

3. Refer to other Division 22 sections for piping materials and methods, sealing pipe penetrations through basement and foundation walls, and fire and smoke barriers; mechanical identification.

1.2 DEFINITIONS:

A. Building Drain: That part of the lowest piping of a drainage system which receives the discharge from soil, waste, and other drainage pipes inside the walls of the building and conveys it to the building sewer to a point 5feet-0inches outside the building wall.

B. Building Sewer: That part of the horizontal piping of a drainage system which extends from the end of the building drain and conveys its discharge to a public sewer, private sewer, individual sewage disposal system, or other point of disposal.

C. Drainage System: Includes all the piping within a public or private premises which conveys sewage, rain water or other liquid wastes to a point of disposal. It does not include the mains of public sewer systems or a private or public sewage treatment or disposal plant.

D. Vent System: A pipe or pipes installed to provide a flow of air to or from a drainage system, or to provide a circulation of air within such system to protect trap seals from siphonage and back pressure.

E. See legend on drawings for additional information.

1.3 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data for all plumbing items including model clearly indicated; operating weights; furnished specialties and accessories; and installation instructions.

B. Shop Drawings: Submit manufacturer's assembly type shop drawings indicating dimensions, required clearances, and methods of assembly of components.

C. Record Drawings: At project closeout, submit record drawings of installed systems products; in accordance with requirements of Division 22.
D. Maintenance Data: Submit maintenance data and parts lists for each type of drain, and accessory; including "trouble-shooting" maintenance guide. Include this data, product data and shop drawings in maintenance manual; in accordance with requirements of Division 22.

1.4 QUALITY ASSURANCE:

A. No-Hub Band Ratings: Roof drain and overflow drain systems are not to exceed band ratings. Add bypass piping between the two systems with 1/8” slope and cleanout to meet this requirement.

B. Regulatory Requirements: Comply with the provisions of the following:
   1. Plumbing Code Compliance: Comply with applicable portions of Local Plumbing Code.
   2. ANSI Compliance: Comply with applicable ANSI standards pertaining to materials, products, and installation of soil and waste systems.
   3. ASSE Compliance: Comply with applicable ASSE standards pertaining to materials, products, and installation of soil and waste systems.
   4. PDI Compliance: Comply with applicable PDI standards pertaining to products and installation of soil and waste systems.
   5. PVC, PP and ABS Pipe: Only Contractor's personnel which have received training in the installation of this material and meet the manufacturer's qualifications shall do the assembly of such material.

1.5 SEQUENCING AND SCHEDULING:

A. Coordinate the installation of roof drains, flashing, and roof penetrations.

B. Coordinate flashing materials installation of roofing, waterproofing, and adjoining substrate work.

C. Coordinate the installation of drains in poured-in-place concrete slabs, to include proper drain elevations, installation of flashing, and slope of slab to drains.

D. Coordinate with installation of sanitary and storm sewer systems as necessary to interface building drains with drainage piping systems.

E. Coordinate all penetrations with Structural Engineer.

F. Coordinate all installations with other trades.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Manufacturer: Subject to compliance with requirements, provide drainage and vent systems from one of the following:

   1. Drainage Piping Specialties, including backwater valves, expansion joints, drains, cleanouts, trap primers, flashing flange and vent flashing sleeve:

2.2 SANITARY AND STORM DRAINAGE, VENT AND SUBSURFACE DRAINAGE PIPE AND FITTINGS:

A. General: Provide piping and pipe fittings complying with Division 22.

2.3 BASIC SUPPORTS AND ANCHORS:

A. General: Provide supports and anchors complying with Division 22.

2.4 DRAINAGE PIPING SPECIALTIES:

A. Backwater Valves: Valve assembly shall be bronze fitted cast-iron, with bolted cover. Flapper shall provide a maximum 1/4inch clearance between flapper and seat for air circulation. Valve ends shall suit piping.

Jay R. Smith Fig. 7012

B. Trap Primers (In or near restrooms, mechanical rooms and plenums): Bronze body valve with automatic vacuum breaker, with 1/2inch connections matching piping system. Complying with ASSE 1018.

1. Valves shall be easily adjusted to high or low pressure and shall be automatically activated whenever any faucet is opened in the building, causing a pressure drop.

2. Connections: Inlet 1/2inch male NPT; outlet 1/2inch female NPT.


4. When more than one (1) trap is to be primed, provide one or more distribution units as required by the manufacturer.

5. Outside Restrooms and Mechanical Rooms: Trap primer alternative (Proset Trap Guard).

C. Expansion Joints: Cast-iron body with adjustable bronze sleeve, bronze bolts with wing nuts.

D. Flashing Flanges: Cast-iron watertight stack or wall sleeve with membrane flashing ring. Provide underdeck clamp and sleeve length as required.

E. Vent Flashing Sleeves: Cast-iron caulking type roof coupling for cast-iron stacks, cast-iron threaded type roof coupling for steel stacks, and cast-bronze stack flashing sleeve for copper tubing.

2.5 CLEANOUTS:

A. Cleanout Plugs: Cast brass, threads complying with ANSI B2.1, and local plumbing code.

B. Floor Cleanout: Round, cast iron body with recessed bronze closure plug; scoriated polished bronze frame and cover plate.

C. Wall Cleanout: Cleanout tee with raised head brass plug tapped for 1/4-20 thread; flat style chrome plated wall cover plate with holes for 1/4inch bolt; 1/4-20 threaded bolt with chrome plated flat head.
D. Surface Cleanout: Cast iron body ferrule with raised head brass plug. Medium duty cast iron manhole cover and ring 12inch diameter to be set in concrete pad, Neenah No. R-1791-A.

E. Line Cleanout: Cast iron tapped cleanout ferrule with raised head brass plug.

2.6 FLOOR DRAINS:

A. Floor drain type designations and sizes are indicated on Drawings.

1. FD-1 Toilet Rooms and Finished Areas

   Round cast iron body with flashing collar and cast iron ring, 6 inch round nickel bronze adjustable strainer head with secured square hole grate, bottom waste outlet.

   Jay R. Smith Fig. 2005-A

2. FD-2 Boiler and Mechanical Rooms

   Round cast iron, light duty, shallow body drain with flashing collar and cast iron ring, 8inches round tractor type non-tilt slotted grate and sediment bucket, bottom waste outlet.

   Jay R. Smith Fig. 2220

3. FD-3 Sterilizer Drain with Waste Funnel

   Round cast iron body with flashing collar and cast iron ring, 6 inch round nickel bronze adjustable strainer head with secured square hole grate, 6inch x 2-1/2inch oval nickel bronze waste funnel attached to top grate, bottom waste outlet.

   Jay R. Smith Fig. 2005-A-F11

4. FD-4 Ice Maker or Drip Pan Drain, Recessed Top Grate

   Round cast iron body with flashing collar and cast iron ring, 7inch round nickel bronze adjustable strainer head with loose set recessed square hole grate, bottom waste outlet. Top outside edge of drain to be set flush with finished floor.

   Jay R. Smith Fig. 2005-A-F37

2.7 FLOOR SINKS:

A. Floor drain type designations and sizes are indicated on drawings.

1. FS-1 Indirect Waste Drain - Kitchen Equipment

   Square, cast iron, porcelain enameled interior, sump body drain 6inch deep x 8inch square with flashing collar and cast iron ring, 8inch square nickel bronze removable half top grate, dome button strainer, bottom waste outlet.

   Jay R. Smith 3100-12

2. FS-2 Dish Wash Machine - Kitchen
Square cast iron, porcelain enameled interior, sump body drain, 16inch square x 12inch deep with 16inch square nickel bronze removable half top grate, bottom waste outlet.

Jay R. Smith 3200-12

2.8 ROOF DRAINS:

A. Roof drain type designations and sizes are indicated on Drawings. Roof drains and overflow drains are to be located within the same pan.

1. RD-1

Cast iron body with sump, removable cast iron vandal-proof dome strainer, cast iron flashing flange and cast iron ring with integral gravel stop, underdeck clamp.

Jay R. Smith Fig. 1010

2. OFD-1 Overflow Drain

Cast iron body with sump, removable cast iron vandal-proof dome strainer, cast iron flashing flange and cast iron clamp with integral gravel stop, cast iron underdeck clamp, standpipe with inlet flow line two (2) inches above the low point of the roof under dome strainer.

Jay R. Smith Fig. 1070

PART 3 - EXECUTION

3.1 EXAMINATION:

A. General: Install piping in accordance with governing authorities having jurisdiction, except where more stringent requirements are indicated.

B. Inspect piping before installation to detect apparent defects. Mark defective materials with white paint and promptly remove from site.

C. Verify all dimensions by field measurements. Verify that all drainage and vent piping and specialties may be installed in accordance with pertinent codes and regulations, the original design, and the referenced standards.

D. Verify all existing grades, inverts, utilities, obstacles, and topographical conditions prior to installations.

E. Examine rough-in requirements for plumbing fixtures and other equipment having drain connections to verify actual locations of piping connections prior to installation.

F. Examine walls, floors, roof, and plumbing chases for suitable conditions where piping and specialties are to be installed.

G. Do not proceed until unsatisfactory conditions have been corrected.

3.2 FOUNDATION PREPARATION FOR UNDERGROUND BUILDING DRAINS:

A. Refer to Division 2 for trenching and backfill requirements.

3.3 INSTALLATION:
A. General Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate the general location and arrangement of the piping systems. Location and arrangement of piping layout take into account many design considerations. So far as practical, install piping as indicated.

B. Install overflow roof drains with the inlet flow line located a maximum 2 inches above the lowest point of roof.

C. All floor drains are to be provided with P-trap the same size as the floor drain unless otherwise noted on mechanical drawings.

D. Provide flashing membrane for all floor drains in structure above slab on grade level; see flashing detail on mechanical drawings.

E. Lubricate cleanout plugs with mixture of graphite and linseed oil. Prior to building turnover remove cleanout plugs, relubricate and reinstall using only enough force to ensure permanent leakproof joint.

F. Provide flashing for all floor drains, floor cleanouts in wet areas and shower drains above grade. Make watertight with Chloraloy 240 underslab moisture vapor barrier as manufactured by the Nobel Co. of Grand Haven, Michigan. Flashing shall extend at least 24 inches from drain rim into floor membrane or on structural floor. Fasten flashing to drain clamp device and make watertight, durable joint. Provide flashing collar extension with all drains and cleanouts installed above grade.

3.4 HANGERS AND SUPPORTS:

A. General: Refer to Section 22 05 29 for supports and anchors.

3.5 INSTALLATION OF PIPING SPECIALTIES:

A. Install backwater valves in sanitary building drain piping as indicated, and as required by the plumbing code. For interior installation, provide minimum 13 inches dia. cleanout cover flush to floor centered over backwater valve cover and of adequate size to remove valve cover for service.

B. Install expansion joints on vertical risers as indicated, and as required by the installation and plumbing code. See plans for detail.

C. Above Ground Cleanouts: Install in above ground piping and building drain piping as indicated, and extend cleanouts to floor or wall above. Line cleanouts not acceptable.

1. As required by plumbing code;
2. At each change in direction of piping greater than 45 degrees below slab;
3. At minimum intervals of 50 feet;
4. At base of each vertical soil or waste stack;
5. At sinks and urinals on grade;
6. At egress of building (surface cleanout).
7. At each water closet or toilet group.
8. Above each urinal at 56” A.F.F.
9. At multiple lavatories at 42” A.F.F.
10. For concealed or non-accessible chases at 42” A.F.F.
11. 6” above the highest trap in main bents on each floor.
12. 6” above trap on isolated vent stacks.

D. Cleanouts Covers: Install floor and wall cleanout covers, types as indicated, and in accessible locations.
E. Flashing Flanges: Install flashing flange and clamping device with each stack and cleanout passing through waterproof membranes.

F. Vent Flashing Sleeves: Install on stacks passing through roof, secure over stack flashing in accordance with manufacturer's instructions.

3.6 PIPE AND TUBE JOINT CONSTRUCTION:
A. Install pipes and pipe joints in accordance with section 22 05 29.

3.7 INSTALLATION OF FLOOR DRAINS:
A. Install floor drains in accordance with manufacturer's written instructions and in locations indicated.
B. Install floor drains at low points of surface areas to be drained, or as indicated. Set tops of drains flush with finished floor.
C. Trap all drains connected to the sanitary sewer with minimum trap size that of drain connected.
D. Install drain flashing collar or flange so that no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes, where penetrated.
E. Position drains so that they are accessible and easy to maintain.

3.8 INSTALLATION OF TRAP PRIMERS:
A. Install trap primers with piping pitched towards drain trap, minimum of 1/8 inch per foot (1 percent). Connect adjacent to nearest flush valve. Adjust trap primer for proper flow.

3.9 INSTALLATION OF ROOF DRAINS:
A. Install roof drains at low points of roof areas, in accordance with the roof membrane manufacturer's installation instructions.
B. Install drain flashing collar or flange so that no leakage occurs between roof drain and adjoining roofing. Maintain integrity of waterproof membranes, where penetrated.
C. Position roof drains so that they are accessible and easy to maintain.
D. Roof and overflow drains shall be in the same pan.

3.10 SERVICE CONNECTIONS:
A. Provide new sanitary/storm sewer services. Before commencing work check invert elevations required for sewer connections, confirm inverts and ensure that these can be properly connected with slope for drainage and cover to avoid freezing.
B. Provide all necessary piping and connections from building drain/storm drain system to connection with city sewer systems in location shown on mechanical site plan.

3.11 CONNECTIONS:
A. Piping Runouts to Fixtures: Provide drainage and vent piping runouts to plumbing fixtures and drains, with approved trap, of sizes indicated; but in no case smaller than required by the plumbing code.
B. Locate piping runouts as close as possible to bottom of floor slab supporting fixtures or drains.

3.12 FIELD QUALITY CONTROL:

A. Inspections:

1. Do not enclose, cover, or put into operation drainage and vent piping system until it has been inspected and approved by the authority having jurisdiction.

2. During the progress of the installation, notify the plumbing official having jurisdiction, at least 48 hours prior to the time such inspection must be made. Perform tests specified in Section 22 05 29 in the presence of the plumbing official.
   a. Rough-in Inspection: Arrange for inspection of the piping system before concealed or closed-in after system is roughed-in, and prior to setting fixtures.
   b. Final Inspection: Arrange for a final inspection to observe the tests specified and to insure compliance with the requirements of the plumbing code.

3. Reinspections: Whenever the piping system fails to pass the test or inspection, make the required corrections, and arrange for reinspection.

4. Reports: Prepare inspection reports, signed by the plumbing official.

B. Piping System Test: Test drainage and vent system in accordance with the procedures of the authority having jurisdiction, or in the absence of a published procedure, as follows, and as described in Section 22 05 29.

3.13 ADJUSTING AND CLEANING:

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Clean drain strainers, domes, and traps. Remove dirt and debris.

3.14 PROTECTION:

A. Protect drains during remainder of construction period, to avoid clogging with dirt and debris, and to prevent damage from traffic and construction work.

B. Place plugs in ends of uncompleted piping at end of day or whenever work stops. Piping shall not be left open ended during construction.

C. Exposed ABS or PVC Piping: Protect plumbing vents exposed to sunlight with 2 coats of water based latex paint. Color selection shall be by Architect.
PART 1 GENERAL

1.1 DESCRIPTION OF WORK:

A. Extent of piping specialties work required by this section is indicated on drawings and schedules and by requirements of this section.

B. Piping specialties furnished as part of factory-fabricated equipment, are specified as part of equipment assembly in other Division 22 sections.

1.2 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of piping specialties of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Codes and Standards:

1. FCI Compliance: Test and rate "Y" type strainers in accordance with FCI 73-1 "Pressure Rating Standard for "Y" Type Strainers". Test and rate other type strainers in accordance with FCI 78-1 "Pressure Rating Standard for Pipeline Strainers Other than "Y" Type".

2. ASME B 31.9 "Building Services Piping" for materials, products, and installation.

3. Safety valves and pressure vessels shall bear the appropriate ASME label.

4. Fabricate and stamp air separators and compression tanks to comply with ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

5. ASME "Boiler and Pressure Vessel Code", Section IX, "Welding and Brazing Qualification" for qualifications for welding processes and operators.

1.3 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data, including installation instructions, and dimensioned drawings for each type of manufactured piping specialty. Include pressure drop curve or chart for each type and size of pipeline strainer. Submit schedule showing manufacturer's figure number, size, location, and features for each required piping specialty.

B. Shop Drawings: Submit for fabricated specialties, indicating details of fabrication, materials, and method of support.

C. Maintenance Data: Submit maintenance data and spare parts lists for each type of manufactured piping specialty. Include this data, product data, and shop drawings in maintenance manual; in accordance with requirements of Division 22.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Manufacturer: Subject to compliance with requirements, provide products by one of the following:
1. Combination Pressure and Temperature Relief Valves:
   a. Amtrol, Inc.
   b. Bell & Gossett ITT; Fluid Handling Div.
   c. Spirax Sarco.
   d. Watts Regulator Co.

2. Pressure Reducing Valves:
   a. Amtrol, Inc.
   b. Armstrong Pumps, Inc.
   c. Bell & Gossett ITT; Fluid Handling Div.
   d. Taco, Inc.
   e. Keckley

3. Pressure Regulating Valves:
   b. Armstrong Machine Works, A-Y Division
   c. Fisher Controls International
   d. Hoffman Specialty ITT; Fluid Handling Div.
   e. Leslie Co.
   f. Spirax Sarco
   g. Spence Engineering Co., Inc.
   h. Wilkins Regulator/Div. Zurn Industries Inc.
   i. Watts Regulator Co.

4. Pipe Escutcheons:
   b. Producers Specialty & Mfg. Corp.

5. Low Pressure Strainers:
   a. Metraflex Co.
   b. R-P&C Valve; Div. White Consolidated Industries, Inc.
   c. Spirax Sarco.
   d. Trane Co.
   e. Victaulic Co. of America.
   f. Watts Regulator Co.

6. Dielectric Waterways
   a. Victaulic Co.
   b. Perfection Corp.
   c. Flow Design Inc.
   d. Perfection Corp.
   e. Rockford-Eclipse Div.

7. Mechanical Sleeve Seal:
   a. Thunderline Corp.
   b. Metra Flex.
2.2 PIPE ESCUTCHEONS:

A. General: Provide pipe escutcheons as specified herein with inside diameter closely fitting pipe outside diameter, or outside of pipe insulation where pipe is insulated. Select outside diameter of escutcheon to completely cover pipe penetration hole in floors, walls, or ceilings; and pipe sleeve extension, if any. Furnish pipe escutcheons with nickel or chrome finish for occupied areas, prime paint finish for unoccupied areas.

B. Pipe Escutcheons for Moist Areas: For waterproof floors, and areas where water and condensation can be expected to accumulate, provide cast brass or sheet brass escutcheons, solid or split hinged.

C. Pipe Escutcheons for Dry Areas: Provide sheet steel escutcheons, solid or split hinged.

2.3 LOW PRESSURE PIPELINE STRAINERS:

A. General: Provide strainers full line size of connecting piping, with ends matching piping system materials. Select strainers for 125 psi working pressure, with Type 304 stainless steel screen. Two inches and smaller steam and liquid strainers shall have 20 mesh screens. Provide 3/64 inch perforations for 2-1/2 inch and 3 inch steam and liquid strainers. Provide 1/8 inch mesh perforations for 4 inches and larger liquid strainers. Provide 1/16 inch mesh perforations for 4 inches and larger steam strainers.

B. Threaded Ends, 2 inch and Smaller: Bronze or Cast-iron body, screwed screen retainer with centered blowdown fitted with pipe plug.

C. Threaded Ends, 2-1/2 inches and Larger: Cast-iron body, bolted screen retainer with off-center blowdown fitted with pipe plug.

D. Flanged Ends, 2-1/2 inches and Larger: Cast-iron body, bolted screen retainer with off-center blowdown fitted with pipe plug.

E. Butt Welded Ends, 2-1/2 inches and Larger: Schedule 40 cast carbon steel body, bolted screen retainer with off-center blowdown fitted with pipe plug.

2.4 DIELECTRIC WATERWAY:

A. General: Zinc electroplated nipple with non metallic lining for use in service indicated, which effectively isolate ferrous from non-ferrous piping (electrical conductance), prevent galvanic action, and stop corrosion. Union style not acceptable. Shall conform to ASA B16.8, plated as applicable a minimum of .0005” and have no flow restrictions when assembled.

2.5 MECHANICAL SLEEVE SEALS:

A. General: Modular mechanical type, consisting of interlocking synthetic rubber links shaped to continuously fill annular space between pipe and sleeve, connected with bolts and pressure plates which cause rubber sealing elements to expand when tightened, providing watertight seal and electrical insulation, as manufactured by Link-Seal or equal.

B. Sleeve Seals: Provide sleeve seals for sleeves located in foundation walls below grade, or in exterior walls, of one of the following:

1. Mechanical Sleeve Seals: Installed between sleeve and pipe.
2.6 FABRICATED PIPING SPECIALTIES:

A. Drip Pans: Provide drip pans fabricated from corrosion-resistant sheet metal with watertight joints, and with edges turned up 2-1/2 inches. Reinforce top, either by structural angles or by rolling top over 1/4 inch steel rod. Provide hole, gasket, and flange at low point for watertight joint and 1 inch drain line connection.

B. Pipe Sleeves: Provide pipe sleeves of one of the following:

1. Sheet-Metal: Fabricate from galvanized sheet metal; round tube closed with snaplock joint, welded spiral seams, or welded longitudinal joint. Fabricate from the following gauges: 3 inches and smaller, 20 gauge; 4 inches to 6 inches 16 gauge; over 6 inch, 14 gauge.

2. Steel-Pipe: Fabricate from Schedule 40 galvanized steel pipe; remove burrs. Provide fully welded waterstop/anchor ring fabricated from minimum 1/8 plate, extending minimum 1 inch from O.D. of sleeve, where noted in Part 3.

3. Iron-Pipe: Fabricate from cast-iron or ductile-iron pipe; remove burrs.

4. Sleeves for use with firestopping shall be fabricated in accordance with the installation instructions of the firestopping system.

PART 3 - EXECUTION

3.1 INSTALLATION OF PIPING SPECIALTIES:

A. Pipe Escutcheons: Install pipe escutcheons on each pipe penetration thru floors, walls, partitions, and ceilings where penetration is exposed to view; and on exterior of building. Secure escutcheon to pipe or insulation so escutcheon covers penetration hole, and is flush with adjoining surface.

B. Strainers: Install strainers full size of pipeline, in accordance with manufacturer's installation instructions. Install pipe nipple and shutoff full port ball valve with ¾ inch hose end and cap in strainer blow down connection. Where indicated, provide drain line from shutoff valve to plumbing drain, full size of blow down connection.

1. Provide strainers in supply line ahead of the following equipment, and elsewhere as indicated.
   a. Pumps
   b. Pressure reducing valves
   c. Temperature or pressure regulating valves

C. Dielectric Waterway: Install at each piping joint between ferrous and non-ferrous piping. Comply with manufacturer's installation instructions. Typical locations are:

1. Water heaters
2. Storage and pressure tanks
3. Water conditioning equipment
4. Changes in service piping materials
5. Make-up connections to boilers.
6. Make-up connections to chilled water systems.

D. Mechanical Sleeve Seals: Loosely assemble rubber links around pipe with bolts and pressure plates located under each bolt head and nut. Push into sleeve and center. Tighten bolts until links have expanded to form watertight seal.
3.2 INSTALLATION OF FABRICATED PIPING SPECIALTIES:

A. Drip Pans: Locate drip pans under piping as indicated. Hang from structure with rods and building attachments, weld rods to sides of drip pan. Brace to prevent sagging or swaying. Connect 1" drain line to drain connection, and run to nearest plumbing drain or elsewhere as indicated.

B. Pipe Sleeves: In fire resistive construction, coordinate the use of sleeves with the firestopping system requirements. See Section 15050. Do not install sleeves through structural members of work, except as detailed on drawings, or as reviewed by Architect. Install sleeves accurately centered on pipe runs. Size sleeves so that piping and insulation will have free movement in sleeve, including allowance for thermal expansion; but not less than 2 pipe sizes larger than piping run. Install length of sleeve equal to thickness of construction penetrated, and finish flush to surface; except floor sleeves where noted below. Provide temporary support of sleeves during placement of concrete and other work around sleeves, and provide temporary closure to prevent concrete and other materials from entering sleeves.

1. Interior gypsum board, plaster, and masonry partitions: Install sheet metal sleeves.
2. Interior cast in place concrete walls: Install steel pipe sleeves.
3. Interior cast in place floors: Install steel pipe sleeves with water stop/anchor ring.
   a. Extend floor sleeves in walls ½ inch above level floor finish of finished rooms and 2 inches above finished floor in all mechanical equipment rooms and pipe chases.
4. Below ground and exterior cast-in-place concrete or masonry: Install steel pipe sleeves with waterstop/anchor ring.
5. For core drilled solid concrete or precast concrete with blockouts, no sleeve is required, except provide sheet metal "collar" fastened and caulked to floors required to have extended sleeves.

END OF SECTION 22 14 23
PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. Extent of water heater work required by this section is indicated on drawings and schedules, and by requirements of this section.

B. Refer to other Division 22 sections for piping, specialties, pumps, fuel piping; breechings which are required external to water heaters for installation; for field installed automatic temperature controls required in conjunction with water heaters; not work of this section.

C. Electrical Work: Refer to Division 22 section "Mechanical/Electrical Requirements for Mechanical Equipment" for requirements.

D. Electrical Work: Provide the following wiring as work of this section, in accordance with requirements of Division 26:

1. Low voltage wiring between water heaters and remote mounted thermostats and controls.

2. Provide factory-mounted and factory-wired controls and electrical devices as specified in this section.

E. Refer to Division 26 sections for other electrical wiring including motor starters, disconnects, wires/cables, raceways, and other required electrical devices; not work of this section.

1.2 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacturer of water heaters of types and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Codes and Standards:

1. UL Compliances: Construct water heaters in accordance with the following UL standards:

   a. UL 174, "Household Electric Storage-Tank Water Heaters".
   b. UL 732, "Oil-Fired Water Heaters".
   c. UL 1261, "Electric Water Heaters for Pools and Tubs".
   d. UL 1453, "Electric Booster and Commercial Storage Tank Water Heaters".

2. Provide water heater components which are UL-listed and labeled.

3. NSF Compliance: Construct and install water heaters located in food service establishments in accordance with NSF 5, "Standard for Hot Water Generating Equipment for Food Service Establishments using Spray Type Dish washing Machines".

4. NEC Compliance: Install electric water heaters in accordance with requirements of NFPA 70, "National Electrical Code".

5. NFPA Compliance: Install gas-fired water heaters in accordance with requirements of NFPA 54, "National Fuel Gas Code".
6. **NFPA Compliance:** Install oil-fired water heaters in accordance with requirements of NFPA 31, "Installation of Oil Burning Equipment".

7. **AGA and NSF Labels:** Provide water heaters which are listed and labeled by American Gas Association and National Sanitation Foundation.

8. **ASME Code Symbol Stamps:** Provide water heaters and safety relief valves which comply with ASME Boiler and Pressure Vessel Code, and are stamped with appropriate code symbols.

9. **ASHRAE Compliance:** Provide water heaters with Performance Efficiencies not less than prescribed in ASHRAE 90A, "Energy Conservation in New Building Design".

### 1.3 SUBMITTALS:

A. **Product Data:** Submit manufacturer's technical product data including rated capacities and efficiencies of selected model clearly indicated; operating weights; furnished specialties and accessories; and installation and start-up instructions.

B. **Shop Drawings:** Submit manufacturer's assembly type shop drawings indicating dimensions, required clearances, and methods of assembly of components.

C. **Wiring Diagrams:** Submit manufacturer's electrical requirements for electrical power supply wiring to water heaters. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring required for final installation of water heaters and controls. Differentiate between portions of wiring that are factory-installed and portions that are to be field-installed.

D. **Record Drawings:** At project closeout, submit record drawings of installed systems products; in accordance with requirements of Division 22.

E. **Maintenance Data:** Submit maintenance data and parts lists for each type and size of water heater, control, and accessory; including "trouble-shooting" maintenance guide. Include this data, product data, shop drawings, and wiring diagrams in maintenance manual; in accordance with requirements of Division 22.

F. **Certificates:** Submit appropriate Certificates of Shop Inspection and Data Report as required by provisions of ASME Boiler and Pressure Vessel Code.

### 1.4 DELIVERY, STORAGE, AND HANDLING:

A. Handle water heaters and components carefully to prevent damage, breaking, denting and scoring. Do not install damaged water heaters or components; remove from site and replace with new.

B. Store water heaters and components in clean dry place. Protect from weather, dirt, fumes, water, construction debris, and physical damage.

C. Comply with manufacturer's rigging and installation instructions for unloading water heaters, and moving units to final location for installation.

### 1.5 SPECIAL PROJECT WARRANTY:

A. **Warranty on Coil, Heat Exchanger, and Burner:** Provide written warranty, signed by manufacturer, agreeing to replace/repair, within warranty period, coils, heat exchangers, and burners with inadequate or defective materials and workmanship, including leakage, breakage, improper assembly, or failure to perform as required; provided manufacturer's instructions for handling, installing, protecting, and maintaining units have been adhered to during warranty period. Replacement is limited to component replacement only, and does not include labor for removal and reinstallation.
1. Warranty Period: 5 years from Date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Condensing Commercial Gas-Fired:
   a. Bock Water Heaters, Inc.
   b. Lockinvar Water Heater Corp.
   c. PVI Industries, Inc.
   d. Rheem Water Heater Div; City Investing Co.
   e. Ruud Water Heater Div; City Investing Co.
   f. Smith Corp. (A.O.); Consumer Products Div.
   g. State Industries, Inc.
   h. Viking Superior Corp.

2.2 CONDENSING COMMERCIAL GAS-FIRED WATER HEATERS:

A. General: Provide condensing style commercial gas-fired water heaters of sizes and capacities as indicated on schedule. Provide certification of design by AGA under Volume III tests for commercial water heaters for delivery of 180 degrees F (82 degrees C) water.

B. Heater: Construct for working pressure of 150 PSI; boiler type hand hole cleanout; magnesium anode rod; 3/4 inch tapping for relief valve; glass lining on internal surfaces exposed to water.

C. Safety Controls: Equip with automatic gas shutoff device to shut off entire gas supply in event of excessive temperature in tank; and pilot safety shutoff.

D. Draft Hood: Equip with AGA certified draft hood.

E. Jacket: Insulate tank with vermin-proof glass fiber insulation. Provide outer steel jacket with baked enamel finish over bonderized undercoating.

F. Accessories: Provide brass drain valve; 3/4 inch pressure and temperature relief valve; and radiant floor shield.

G. Controls: Provide gas pressure regulator; pilot gas regulator; thermostat; and temperature limit control.

PART 3 - EXECUTION

3.1 EXAMINATION:

A. Examine areas and conditions under which water heaters are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION OF WATER HEATERS:

A. General: Install water heaters in accordance with manufacturer's installation instructions. Install units plumb and level, firmly anchored in locations indicated, and maintain manufacturer's recommended clearances.
B. Support: Place units on concrete pads, orient so controls and devices needing service and maintenance have adequate access.

C. Piping: Connect hot and cold water piping to units with shutoff valves and unions. Connect recirculating water line to unit with shutoff valve, check valve, and union. Extend relief valve discharge to closest floor drain, or as indicated.

D. Gauges: Provide thermometers on inlet and outlet piping of water heaters, in accordance with Basic Mechanical Materials and Methods Section "Meters and Gauges."

E. Gas-Fired Water Heaters: Connect gas supply to gas line with drip leg, tee, gas cock, and union; full size of unit inlet connection. Locate piping so as not to interfere with service of unit.

1. Flue: Connect flue to draft hood with gas-tight connection. Provide flue of minimum size as flue outlet on heater. Comply with gas utility requirements.

F. Acid Neutralizer: Provide manufacturers standard acid neutralization kit and pipe indirectly to newest floor drain.

3.3 FIELD QUALITY CONTROL:

A. Start-Up: Start-up, test, and adjust gas-fired water heaters in accordance with manufacturer's start-up instructions, and utility company's requirements. Check and calibrate controls, adjust burner for maximum efficiency.

B. Start-up: Start-up, test, and adjust electric water heaters in accordance with manufacturer's start-up instructions. Check and calibrate controls.

C. Start-Up: Start-up, test, and adjust oil-fired water heaters in accordance with manufacturer's start-up instructions. Check and calibrate controls, adjust burner for maximum efficiency.

3.4 CLOSEOUT PROCEDURES:

A. Training: Provide services of manufacturer's technical representative for 1-half day to instruct Owner's personnel in operation and maintenance of water heaters.

1. Schedule training with Owner, provide at least 7-day notice to Contractor and Engineer of training date.

END OF SECTION 22 34 00
SECTION 22 40 00
PLUMBING FIXTURES

PART 1 – GENERAL

1.1 DESCRIPTION OF WORK:

A. Extent of plumbing fixtures work required by this section is indicated on drawings, schedules and included in this section.

B. This section specifies plumbing fixtures and trim. The types of fixtures specified included but are not limited to the following: See also Plumbing Fixture Schedule on drawings.

1. Water Closets
2. Urinals
3. Lavatories (including wheelchair type)
4. Sinks
5. Showers (prefabricated and receptors)
6. Fixture Supports (including wheelchair type)
7. Faucets
8. Flush Valves
9. Toilet Seats
10. Drinking Fountains
11. Mop Service Basins
12. Emergency Showers and Eyewash
13. Fittings, Trim and Accessories
14. Lavatory/Undersink ADA Pipe Covers

1.2 QUALITY ASSURANCE:

A. Codes and Standards:

2. ARI Standard 1010: "Drinking-Fountains and Self-Contained Mechanically-Refrigerated Drinking-Water Coolers"
5. UL Standard 399: "Drinking-Water Coolers."
7. NSF Standard 61: "Drinking Water Components."

B. Where fixtures are specified as handicapped, it shall be the sole responsibility for all manufacturers and/or suppliers to provide plumbing fixtures and related trim which meets or exceeds the ADA requirements.
1.3 SUBMITTALS:

A. Product Data: Submit product data and installation instructions for each fixture, faucet, specialties, accessories and trim specified; clearly indicate rated capacities of selected models of water coolers.

B. Shop Drawings: Submit rough-in drawings with brand names on each sheet and item. Detail dimensions, rough-in requirements, required clearances and methods of assembly of components and anchorages. Coordinate requirements with Architectural casework shop drawings specified in Division 6 for fixtures installed in countertops and cabinets. Furnish templates for use in casework shop.

C. Wiring Diagrams: Submit manufacturer's electrical requirements and wiring diagrams for power supply to units. Clearly differentiate between portions of wiring that are factory installed and field installed.

D. Color Charts: Submit manufacturer's standard color charts for cabinet finishes and fixture colors.

E. Maintenance Data: Submit maintenance data and spare parts lists for each type of manufactured plumbing fixture, valve and trim. Include this data, product data and shop drawings with maintenance manual in accordance with requirements of Division 15.

F. Submit certification of compliance with specified ANSI, UL and ASHRAE Standards.

G. Submit certification of compliance with performance verification requirements specified in this section.

1.4 DELIVERY, STORAGE AND HANDLING:

A. Store fixtures where environmental conditions are uniformly maintained within the manufacturers recommended temperatures to prevent damage.

B. Store fixtures and trim in the manufacturer's original shipping containers. Do not stack containers or store in such a manner that may cause damage to the fixture or trim.

1.5 SEQUENCING AND SCHEDULING:

A. Schedule rough-in installations with the installation of other building components.

1.6 MAINTENANCE:

A. Extra Stock:

1. Furnish special wrenches and other devices necessary for servicing plumbing fixtures and trim to Owner with receipt in a quantity of one device for each 10 fixtures, minimum of one wrench and one device.

2. For each type of faucet, furnish faucet repair kits complete with all necessary washers, springs, pins, retainers, packings, O-rings, sleeves and seats in a quantity of 1 kit for each 40 faucets, minimum one repair kit per faucet type.

PART 2 – PRODUCTS

2.1 MANUFACTURERS:

A. Manufacturer subject to compliance with requirements, provide products by one of the following specified manufacturers:

1. Water Closets:
1. Plumbing Fixtures:
   a. American Standard
   b. Kohler
   c. Toto
   d. Zurn

2. Urinals:
   a. American Standard
   b. Kohler
   c. Zurn

3. Lavatories:
   a. American Standard
   b. Kohler
   c. Zurn

4. Sinks:
   a. American Standard
   b. Kohler
   c. Zurn

5. Stainless Steel Sinks:
   a. Elkay
   b. Just

6. Prefabricated Showers:
   a. Lasco

7. Fixture Carriers and Supports:
   a. Josam
   b. J.R. Smith
   c. Zurn

8. Faucets:
   a. Chicago Faucets
   b. Elkay
   c. Kohler
   d. T & S Brass

9. Flush Valves:
   a. Sloan
   b. Zurn
   c. American Standard
   d. Kohler
   e. Toto

10. Shower Valves:
    a. Symmons
    b. Powers
11. Water Closet Seats:
   a. Church
   b. Kohler

12. Electric Water Coolers:
   a. Elkay
   b. Halsey Taylor
   c. Haws Drinking Faucet

13. Drinking Fountains:
   a. American Standard
   b. Elkay
   c. Kohler

14. Mop Service Basins:
   a. Fiat
   b. Florestone
   c. Manstone

15. Shower Receptors:
   a. Fiat
   b. Florestone
   c. Manstone

16. Emergency Fixtures:
   a. Bradley
   b. Haws
   c. Speakman

17. Flexible Supplies, Stops & Traps:
   a. McGuire
   b. Brasscraft

18. Undersink/Lavatory ADA Pipe Covers:
   a. McGuire
   b. True Bro

2.2 FIXTURES:

A. Water Closets

2. Color: White, unless specified otherwise.
3. Action: Siphon jet 1.6 gpf maximum.
4. Rim: Elongated round front.
5. Trim: All trim shall be chrome plated, cast brass or copper tube. Plastics or metal alloy base type material will not be acceptable.
6. Support: All wall hung fixtures shall be supported from the building structure with floor mounted carriers. Do not support from walls. Support with ½” bolts.
7. Rough-in dimension: Floor mounted fixtures shall be mounted 17” to 19” from finished floor to top of seat.
8. Cleanouts: Provide cleanouts as shown on drawings or per the applicable Plumbing Code.
9. Operating handle for tank or manual flush valve shall be located and operable on the wide side of the ADA toilet compartment. Standard or non-ADA installations, facing front of the fixture, shall have tank handle or flush valve handle located on left side with the flush valve supplied from the right side.
10. China bolt caps for floor set fixture shall be set in place with “plaster of paris”.
11. Chrome plated cap nuts for wall hung fixtures shall be installed with strap wrench to prevent marring.
12. Provide wax or neoprene waste outlet sealing ring for floor set and wall hung fixtures.
13. Cast iron, red brass or PVC threaded nipples (where permitted by jurisdictional codes) for wall hung fixture connections to carrier.
14. Provide fully glazed trapways. Partial glazing is not acceptable.
15. Provide non-hardening silicone base sealant with coved finish between fixture and floor for floor set units and wall for wall mount fixtures. Color of sealant to match fixture color.
16. All fixtures shall be set rigidly, level, plumb and spaced in compliance with jurisdictional requirements.
17. Flush valves shall be anchored behind walls to eliminate and push-pull, horizontal or vertical movement.
18. Contractor shall adjust flush valve to proper flow rates for appropriate wash and flush water volume to match the intended flush action for the installed units.

B. Urinals

2. Color: White, unless specified otherwise.
3. Flush action: Match specified urinal flush rating and appropriate flush valve.
4. Trim: All trim shall be chrome plated, cast brass or copper tube. Plastics or metal alloy base type material will not be acceptable.
5. Support: Carrier mounted with cast iron nipple and galvanized steel pipe using floor mounted hanger and bearing plate type carrier. Wood wall supports or plates are not acceptable for wall mounted fixtures.
6. Rough-in dimension: For ADA compliance, install per the requirements of the accessibility guidelines, section 4.18 Urinals, of the act. Standard mounting height is 24” from finished floor to the rim. ADA mounting height is 17” or as detailed on architectural drawings.
7. Cleanouts: Provide cleanouts as shown on drawings or per the applicable Plumbing Code.
8. Provide with anti-backsplash wall.
9. Provide with top or back mounted ¾” spud to match the flush valve specified.
10. Space units in accordance with jurisdictional code.
11. All fixtures shall be set rigidly, level, plumb and spaced in compliance with jurisdictional requirements.
12. Flush valves shall be anchored behind walls to eliminate and push-pull, horizontal or vertical movement.
13. Contractor shall adjust flush valve to proper flow rates for appropriate wash and flush water volume to match the intended flush action for the installed units.

C. Lavatories

1. Material: Vitreous china or type 302/304 stainless steel as specified. Enameled cast iron lavatories may be used when specifically specified. Plastic formed or enameled steel lavatories are not acceptable unless specified otherwise.
2. Color: White, unless specified otherwise.
3. Mounting: Wall hung from floor mounted top & bottom bearing plate or concealed arm carrier. Wall mounted wood or metal blocking hangers will not be permitted. Counter mounting, self-rimming or composite countertop with integral bowl will be permitted when specified.

4. Rough-in dimension: See architectural drawings for specific installation placement dimensions and required mounting heights.

5. Cleanouts: Provide cleanouts as shown on drawings or per the applicable Plumbing Code.

6. Faucet hole drilling: Drilling shall be provided by the fixture manufacturer to match the required fixture mounting and accessories specified by this and other sections of the plans and specifications. Faucet hole covers will not be acceptable.

7. Size and style of listed acceptable units shall match the specified unit including appearance, shrouds, enclosures, soap depressions, front or rear overflows, flat slab rim, splash back, shelf back side shields, etc.

D. Sinks

1. Material: Stainless steel, 18-gauge. Type 316 stainless steel high nickel content for laboratories and school laboratories.

2. Color: No. 4 satin finish for stainless steel. White, for enameled cast iron, unless specifically specified otherwise. Composites as specified.

3. Mounting: Wall mounted and carrier mounted sinks shall be installed per manufacturer recommendations and instructions.

4. Rough-in dimension: Rough-in and mounting shall conform to manufacturer product mounting recommendations and architectural details including casework, counter dimensions. Provide only the largest dimensional sink unit that fits in the available space.

5. Cleanouts: Provide cleanouts as shown on drawings or per the applicable Plumbing Code.

6. Faucet hole drillings shall match the faucet configuration and accessories specified in the mechanical and architectural documents, i.e. dishwasher air gaps, liquid dispensers, remote drain operators, eye washes, etc. when mounted in the sink back ledge. Note: Faucet hole covers will not be acceptable. Contractor to coordinate prior to ordering sinks.

7. Stainless steel sinks to be sound deadened with undercoating.

E. Prefabricated Showers


2. Color: White, unless specified otherwise.

3. Rough-in Dimension: Rough-in and mounting shall conform to manufacturer product mounting recommendations and architectural details including wall framing, tile or casework.

4. Provide center drain with a brass or stainless steel shower drain cover.

5. Floor shall have a slip-resistant, textured bottom.

6. Provide reinforcement of shower where grab bars are specified.

2.3 FIXTURE SUPPORTS AND CARRIERS:

A. ADA Water Closet Supports: Commercial grade adjustable, factory painted, cast iron face plate, support base and appropriate type waste fitting having face plate gasket; zinc plated steel fixture studs and fasteners; coated and threaded adjustable wall coupling with neoprene closet outlet gasket; and chrome plated fixture cap nuts and fiber fixture washers. Units shall have elevated mounting heights of wheelchair fixtures, siphon jet or blow-out action water closet and type of sanitary piping system to which it is connected.

B. Lavatory Supports: Commercial grade cast iron supports, having tubular steel uprights with concealed arms and sleeves, mounted on adjustable headers and complete with heavy cast iron short feet bolted to floor, alignment trusses and mounting fasteners.
2.4 FAUCETS:

A. Lavatory Trim

1. All lavatory faucets shall be provided with laminar flow controls for 2.2 or 2.5 gpm in lieu of aerators or as specified otherwise.
2. All lavatory faucets shall be provided with ceramic disc cartridges or as specified otherwise.

B. Sink Trim

1. All sink faucets shall be provided with laminar flow controls for .5 gpm in lieu of aerators or as specified otherwise.
2. All sink faucets shall be provided with ceramic disc cartridges or as specified otherwise.
3. Alternate faucet controls, i.e. self-closing, knee operated, foot operated, etc. shall be provided complete with all necessary anchoring and mounting devices recommended and supplied by the device manufacturer.
4. All sink faucets shall be chrome plated brass complying with restrictions for lead content for the requirements of the jurisdiction or district. Types include hand, foot, knee, infra-red or heat sensing type operations.
5. IR faucets must be provided with integral stops.

C. Mop Service Basin Trim

1. All mop service basin faucets shall be wall mounted, all brass supply faucet, 10” spout with wall brace, ¾” male hose thread outlet and vacuum breaker, lever handles, wall flanges and ½” female thread inlets and rough chrome plated finish.
2. Faucets must be provided with integral stops.

2.5 FLUSH VALVES:

A. Description: Exposed type, quiet action, all brass, chrome plated, oscillating non hold open handle, 1" screwdriver angle stop with vandal resistant cap, vacuum breaker, 1-1/2" flushing connection with tailpiece, spud coupling for 1-1/2" top spud, wall and spud flanges, sweat solder adaptor, low consumption of 1.6 gpf or less, handle shall conform to ADA requirements.

B. Coating: Provide certified coated flush valve with permanent anti-bacterial coating by the manufacturer including commercial and all medical facilities and medical use areas.

C. Provide battery or I.R. operation, where specified, with manual override button.

D. All flush valves shall have a properly sized water hammer arrestor. Refer to section 22 14 23, “Water Distribution Piping” for water hammer arrestors.

2.6 WATER CLOSET SEATS:

A. Material: Solid plastic, high impact commercial weight. Provide with permanent anti-bacterial treatment by the manufacturer unless specified otherwise.

B. Color: Color shall be black per UCB Standards.

C. Provide elongated open front, less cover, notched rear and stainless steel hinge posts with self-sustaining check hinges.
2.7 DRINKING FOUNTAINS:

A. Recessed Wall Mounted Drinking Fountain

1. Material: Vitreous china or stainless steel as specified.
2. Color: White, unless specified otherwise.
3. Mounting: Wall hung from floor mounted top & bottom bearing plate or concealed arm carrier. Wall mounted wood or metal blocking hangers will not be permitted.
4. Rough-in dimension: See architectural drawings for specific installation placement dimensions and required mounting heights.
5. Receptors: For stainless steel drinking fountain, provide heavy gauge stainless steel, with No. 4 finish on the outside.
6. Bubblers and Valves: Chrome plated brass bubbler head, stream control, push button valve with bubble designed to provide uniform stream without spurting. Push button shall not be plastic.
9. Cleanouts: Provide cleanouts as shown on drawings or per the applicable Plumbing Code.

2.8 MOP SERVICE BASINS:

A. MSB-1 – Mop Service Basin

1. Material: Precast terrazzo.
2. Rough-in Dimension: Rough-in and mounting shall conform to manufacturer product mounting recommendations and architectural details including wall framing, tile or casework. Coordinate custom drain location with job conditions.
3. Provide stainless steel guards on all sides.
4. Provide stainless steel drain with removable stainless steel strainer.
5. Provide stainless steel splash panels to protect walls above rim.

2.9 EMERGENCY FIXTURES:

A. Emergency Shower – Refer to plumbing fixture schedule.

1. Description: Deluge shower with overhead supply and internal 20 gpm regulator for flow control.
2. Finish: Chrome finish
3. Valve: 1” brass stay-open valve with chrome finish and aluminum triangular pull rod.
4. Performance: Capable of 20 gpm @ 20 psi.
5. Emergency showers shall be served by a thermostatic mixing valve.

B. Emergency Eyewash – Refer to plumbing fixture schedule.

1. Description: Stainless steel bowl, two aerated spray outlets with flip-top dust caps.
2. Valve: ½” brass stay-open valve with chrome finish and stainless steel push handle.
3. Performance: Capable of 3.6 gpm @ 30 psi
4. Emergency eyewash shall be served by a thermostatic mixing valve or other tempering valve.

2.10 FITTINGS, TRIM, AND ACCESSORIES:

A. Stops and Supplies for Water Closets: Polished, chrome-plated, brass stem, loose key, ¼-turn angle stop having 1/2" inlet and 3/8" O.D. x 12" long braided stainless steel flexible tubing outlet with collar, wall flange and escutcheon plate. Quantity to match trim specified. Deliver all extra handles to Owner.
B. Stops and Supplies for Lavatories and Sinks: Polished, chrome-plated, brass stem, loose key, ¼-turn angle stop having 1/2" inlet and 3/8" O.D. x 12" long braided stainless steel flexible tubing outlet with collar, wall flange and escutcheon plate. Quantity to match trim specified. Deliver all extra handles to Owner.

C. Sink Strainers: All sink strainers shall be “Spin-N-Grin” type models unless specifically specified otherwise.


E. Traps for Sinks: Cast brass, 1-1/2" with set screw escutcheon or 2" adjustable "P" trap and waste to wall.

F. Tub Waste and Overflow Fittings: 17-Gauge brass bath waste and overflow, chrome-plated waste spud with universal type outlet connection suitable for 1-1/2" I.P.S., 1-1/2" O.D. tubing, or 1-1/2" solder joint outlet connection on waste tee.

G. Escutcheons: Chrome-plated cast brass with set screw.

H. All ADA accessible lavatories and sinks shall have the supply and waste piping insulated with lavatory/undersink ADA covers.

2.11 LAVATORY/UNDERSINK ADA COVERS:

A. ADA Accessible Lavatories and Sinks: Provide white, molded antimicrobial vinyl cover for stops, supplies, trap and tailpiece.

PART 3 – EXECUTION

3.1 EXAMINATION:

A. Verify all dimensions by field measurements. Verify that all plumbing fixtures may be installed in accordance with pertinent codes & regulations, the original design and the referenced standards.

B. Examine rough-in for potable water and waste piping systems to verify actual locations of piping connections prior to installing fixtures.

C. Examine walls, floors and cabinets for suitable conditions where fixtures are to be installed.

D. Do not proceed until unsatisfactory conditions have been corrected.

3.2 INSTALLATION:

A. Install plumbing fixtures level and plumb in accordance with fixture manufacturer's written instructions, rough-in drawings, pertinent codes & regulations, the original design and the referenced standards.

B. Fasten plumbing fixtures securely to supports or building structure. Secure supplies behind or within wall construction to provide rigid installation.

C. Set prefabricated showers, shower receptors and mop service basins in a leveling bed of cement grout, material recommended by manufacturer or material specified by Architect.

D. Install fixture water stop valves in accessible locations.
E. Install set screw escutcheons at each wall, floor and ceiling penetration in exposed finished locations and within cabinets and millwork.

F. Seal fixtures to walls and floors using non-hardening silicone sealant as specified in Division 7. Match sealant color to fixture color, except for stainless steel sinks.

G. Where possible, fixtures shall be product of one manufacturer.

H. Install hose end faucets and hose connection with field testable backflow preventers or vacuum breakers.

I. Solidly attach floor mounted water closets to floor with hex expansion shield of cast iron closet flanges.

3.3 ADA ACCESSIBILITY:
A. Review Mechanical and Architectural drawings to determine fixtures requiring ADA accessibility. Notify Architect/Engineer of any physical conflicts preventing full dimensional compliance prior to beginning work.

B. Comply with the installation requirements of ANSI A117.1 and Public Law 90-480 with respect to plumbing fixtures for the physically handicapped. Arrange flush valve/flush tank handles with proper orientation to meet ADA requirements.

3.4 FIELD QUALITY CONTROL:
A. Test fixtures to demonstrate proper operation upon completion of installation and after units are water pressurized. Replace malfunctioning units, then retest.

B. Inspect each installed unit for damage. Replace damaged fixtures.

3.5 ADJUSTING:
A. Adjust water pressure at drinking fountains, faucets, shower valves and flush valves to provide proper flow and stream.

B. Replace washers of leaking or dripping faucets and stops.

3.6 CLEANING:
A. Clean fixtures, trim and strainers using manufacturer's recommended cleaning methods and materials prior to final turnover to Owner.

3.7 PROTECTION:
A. Provide protective covering for installed fixtures, water coolers and trim as required by this section.

B. Do not allow use of fixtures for temporary facilities unless expressly approved in writing by the Owner.

3.8 FIXTURE MOUNTING HEIGHT SCHEDULE:
A. Fixture mounting height and rough-in dimensions shall be per ADA requirements or as indicated on the architectural drawings and specifications.
### 3.9 WATER CONSERVATION:

A. All plumbing fixtures shall be of water conservation design. As a minimum, provide devices to restrict water flow as follows:

1. Lavatory 0.5 gpm maximum
2. Sink 2.5 gpm maximum
3. Mop Sink 1.6 gpm hot and 1.6 gpm cold maximum
4. Water Closets (siphon jet) 1.6 gpf maximum  
   (Dual Flush for Women’s R.R.) (1.6/1.1)
5. Urinals (siphon jet) 1.8 gpf maximum
6. Shower Heads 2.5 gpm maximum

B. Flow control devices shall maintain flow rate shown regardless of inlet pressure.

END OF SECTION 22 40 00
PART 1 GENERAL

1.1 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of laboratory gas systems equipment and products, of types, materials, and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Installer Qualifications: Firm with at least 3 years of successful installation experience on projects with laboratory gas systems work similar to that required for project. Individual installers shall be qualified in accordance with ASME Boiler and Pressure Vessel Code, Section IX as modified by NFPA 99.

1. On site supervisors shall have completed a 32 hour training course on the installation of laboratory gas systems in accordance with ANSI requirements.

C. Codes and Standards:

1. ASME Compliance: Provide laboratory gas pressure vessels and relief valves in accordance with ASME "Boiler and Pressure Vessel Code"; provide ASME Code Symbol Stamp.

2. ASME Compliance: Fabricate and install laboratory gas systems in accordance with ASME B31.9 "Building Service Piping".

3. UL Compliance: Provide electrical components which are UL-listed and have UL label affixed.

4. All equipment supplied under this section shall be compatible with existing secondary equipment, if any.

5. Laboratory compressed air shall be oil free air complying, as a minimum with Grade D in Compressed Gas Association, Inc., pamphlet G-7.1, commodity specification for air, and having a maximum dew point of -20 degrees F. (-28.9 degrees C.).

1.2 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data and installation instructions for laboratory gas systems materials and products.

B. Shop Drawings: Submit scaled layout drawings of laboratory gas systems pipe and fittings including, but not necessarily limited to, pipe and tube sizes, locations, elevations and slopes of horizontal runs, wall and floor penetrations, equipment connections, and gas outlets. Indicate interface and spatial relationship between piping and proximate equipment.

C. Record Drawings: At project closeout, submit record drawings of installed systems products; in accordance with requirements of Division 22.

D. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to units. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

E. Maintenance Data: Submit maintenance data and parts lists for Laboratory gas systems materials and products. Include this data, product data, shop drawings, record drawings, and wiring diagrams in maintenance manual; in accordance with requirements of Division 22.
F. Installer Qualifications: Submit installer qualifications, including brazing certifications and laboratory gas training documentation.

1.3 DELIVERY, STORAGE, AND HANDLING:

A. Deliver laboratory gas equipment, including air compressors, vacuum pumps, and gas storage units with factory-installed shipping skids; accessories packaged in factory-fabricated fiberboard containers; and pipe/tube with plastic end-cap protectors to prevent pipe-end damage and to eliminate dirt and moisture from entering interior of pipe/tube.

B. Handle laboratory gas piping and equipment carefully to avoid damage to components, enclosures and finishes. Do not install damaged equipment; replace and return damaged units to equipment manufacturer.

C. Store laboratory gas piping and equipment indoors and protect from weather and construction traffic.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS:

A. Manufacturer: Subject to compliance with requirements, provide laboratory gas systems products by one of the following:

1. Vacuum Pumps:
   a. Becker
   b. Busch
   c. Quincy
   d. Squire Cogswell
   e. SIHI
   f. Allied Health
   g. Reitschle
   h. Beacon

2. Oil-Less Laboratory Air Compressors:
   a. Quincy
   b. Allied Healthcare Products
   c. Atlas Copco
   d. Beacon
   e. SIHI
   f. Powerex

3. Air Purifier:
   a. Deltech Engineering, Inc.

4. Refrigerated Dryer:
   a. Hankison
   b. Wilkerson

5. Dessicant Dryer:
2.2 MATERIALS AND PRODUCTS:

A. General: Provide piping materials and factory-fabricated piping products of sizes, types, pressure ratings, temperature ratings, and capacities as indicated.

2.3 BASIC IDENTIFICATION:

A. General: Provide identification complying with Division 22 section "Mechanical Identification".

2.4 BASIC PIPES AND PIPE FITTINGS:

A. Laboratory Gas Piping: All above and below grade pipe for oxygen, nitrous oxide, nitrogen, vacuum and compressed air shall be minimum 1/2 inch (3/4 inch for vacuum) Type K or L copper tubing (ASTM B819), hard drawn, seamless copper tubing, except that "pigtails" of not less than 3/8 inch OD for positive pressure gasses, 1/2 inch OD for vacuum, soft annealed tubing, not exceeding 8 inches, may be used at outlets. Pipe shall be factory prewashed, oxygen clean grade, capped and labeled by pipe supplier and delivered sealed to the job site.

B. All fittings used for connecting copper tubing shall be wrought copper brazing fittings complying with MSS SP-73, suitable for brazed connections and especially prepared by the manufacturer for oxygen service.

C. All joints in the piping shall be made with copper-phosphorus-silver brazing alloy with 15 percent silver content, BcuP-5, without flux, melting range 1190-1480 deg F.

2.5 BASIC PIPING SPECIALTIES:

A. General: Provide piping specialties complying with Division 15 Section 15120 "Piping Specialties."

2.6 BASIC SUPPORTS AND ANCHORS:

A. General: Provide supports and anchors, complying with Division 22 "Supports and Anchors", in accordance with the following listing:

1. Extension split pipe clamp, copper plated, hinged or 2-bolt for pipe support from any substrate.

2.7 IN-LINE SHUTOFF VALVES:

A. Shutoff Valves: Provide laboratory gas (3 piece) shutoff valves, bronze-body, double seal, full flow, union ball type, with seat seals and stem seals. Design so quarter turn of lever-type valves handle is maximum travel between open and closed positions. Design for working pressure of 300 psi minimum. Provide valves with color-coded gas identification labels.

2.8 BASIC VIBRATION CONTROL:

A. General: Provide vibration control products in accordance with the following listing:

1. Air Compressors and Vacuum Pumps:

   a. Fabricate equipment base and spring isolators.
   b. Vibration mounting pads to solid mass and per equipment manufacturer's instructions.
   c. Refer to 230548 for additional requirements.
2.9 LABORATORY GAS EQUIPMENT AND ACCESSORIES:

A. General: Provide factory-fabricated laboratory gas accessories of sizes, types, ratings and capacities indicated. Where type is not indicated, provide components and equipment complying with NFPA 99, and as determined by Installer to comply with installation requirements.

2.10 LABORATORY AIR COMPRESSOR:

A. All components shall be at least duplexed and valved to permit service to any component without interrupting air supply to the facility.

B. The system shall be a complete plant consisting of compressors, receiver and controls capable of providing scheduled SCFM with one compressor out of service. Dew point and CO monitors shall be prewired on a system not requiring separate power source. Dew point monitor shall be the ceramic type. Chilled mirror or aluminum oxide sensors are not acceptable.

C. System shall be completely factory assembled, requiring only interconnection between modules on site. Systems requiring site assembly other than interconnection are not acceptable (remounting of components removed for shipping is permitted). System shall include additional interconnecting valves, piping and wiring to allow up to 2 additional compressors to be added in the future.

D. Each compressor shall have a piped intake manifold with one inline inlet air filter with isolation valve. The inlet filter housing shall be isolated from the intake manifold by a braided 304 stainless steel flex connector. The inlet filter housing shall allow vertical access for replacement of the filter cartridge, and shall minimize dirt falling into the compressor intake during service. The compressor discharge line shall include a flex connector, safety relief valve, isolation valve and check valve.

E. The control system shall be NEMA 12 and UL labeled. This control system shall provide automatic lead/lag sequencing with circuit breaker disconnects for each compressor, full voltage motor starters with overload protection, redundant 120 volt control circuit transformers, phase reversal protection, visual and audible reserve unit alarm with isolated contacts for remote alarm. HOA lighted selector switches, pressure gauge, and runtime meters for each pump. The motors shall be a NEMA rated, open dripproof unit with 1.15 service factor suitable for 208 or 230/460 volt. All electrical disconnects shall be internal to the main control cabinet and protected by the safety interlock of that cabinet. Pumps shall not run in hand mode if pressure on receiver has been satisfied. Visual and audible alarm indication for high discharge air temperature shutdown with isolated contacts for remote alarm shall be included. A temperature sensor shall be provided at the outlet of each compressor heat to provide hi-temp alarm and shutdown that compressor. Dryers shall be controlled from main control panel with selector switches mounted on control panel.

F. Each desiccant dryer must be individually sized for peak calculate demand of the entire package, plus two more future compressors, and capable of producing a 10 degree F (-12 degree C) pressure dew point. Dryer purge flow shall be minimized through an integral demand based purge saving control system that shall include a transfer valve utilizing two ceramic slide plates that is covered by a 10-factory warranty. Units utilizing multiple solenoids or diaphragm type switching are not acceptable. Refrigerated dryers are not acceptable. The inlet to each dryer shall include a mounted prefilter rated for 0.01 micron with automatic drain and element change indicator. Fully duplexed final line filters rated for 0.01 micron with element change indicators and duplexed final line regulators and duplexed safety relief valves shall be factory mounted and piped.

G. All moving parts (fans, pulleys and belts) shall be fully protected by an OSHA approved enclosure. All support structures shall be minimum of 10 gauge steel. The compressor modules and motors shall be fully isolated from the main compressor base by means of a four point, heavy-duty isolation system for
a minimum of 95 percent isolation efficiency. Engineering data shall be provided supporting efficiency and equal weight distribution between supports.

H. System piping shall be brazed except where unions are required. Systems using rubber flex connectors with hose clamps are not allowed. The air receiver shall be corrosion resistant, ASME Coded, National Board Certified, rated for a minimum 150 psig design pressure and include a liquid level glass, safety relief valve, manual drain valve, and a screened automatic solenoid valve. During normal operation the flow of air will travel through the tank to allow water to condense in tank. The complete package shall be prewired, pre-piped and assembled on one common base with single point connections for electrical, intake air, discharge air, and condensate drains.

I. The compressors shall be an oil-less scroll type as follows:

1. The compressors shall be continuous duty rated with sealed bearings. The design shall be single stage, air-cooled, consisting of one fixed and one orbiting scroll sealed with PTFE tip seals between the scroll halves and rated for 120 psig discharge pressure.

2. Heat dissipation shall be achieved through an integral cooling fan and air ducting. The compressors shall be v-belt drive with an OSHA approved beltguard, and a sliding motor mounting base.

3. The motor shall be a NEMA rated, open dripproof, 3600 RPM, with 1.15 service factor suitable for 208 or 230/480V electrical services.

4. Each compressor shall have a temperature shutdown switch.

5. The compressor module discharge line shall include a flex connector, safety relief valve, isolation valve and an integral valve to provide load-less starting.

6. The discharge flex connector shall be braided 304 stainless steel, brass or bronze.

J. Air Receiver:

1. The vertical air receiver shall be corrosion resistant, ASME Coded, National Board Certified, rated for a minimum 150 psig design pressure and include a liquid level gauge glass, safety relief valve, manual drain and timed automatic solenoid drain valve.

K. Dew Point Hygrometer/CO Monitor:

1. The package shall incorporate a dew point hygrometer and CO monitor that are both pre-wired to include remote alarm contacts, as well as pre-piped. The digital dew pong display shall be mounted in the main control panel. The dew point sensor shall be the ceramic type (aluminum oxide type is not acceptable) with system accuracy of ± degree F.

2. The CO sensor shall be a chemical type with system accuracy of ±2PPM (at 10PPM) for carbon monoxide. The dew point alarm shall be factory set at 4 degree C (39 degree F) per NFPA 99, and the CO alarm shall be factory set at 10PPM. Both set points shall be field adjustable.

3. High CO and high dew point conditions shall be indicated with visual and audible alarms.

L. Additional Components:

1. Local Alarm Panel Indicating:

   a. Dewpoint
b. Back-up compressor operating  
c. High water level in receiver  
d. High water level in separator  
e. High discharge air temperature  
f. High carbon monoxide levels  

2.11 VACUUM PUMP:  

A. Vacuum pump shall be an expandable/modular triplex central vacuum system consisting of three vacuum pumps mounted on a common skid with expandable automatic alternating electrical controls and a vertical receiver.  

B. Each vacuum pump shall be a lubricated rotary vane type.  

C. Each vacuum pump shall be direct-drive by a TEFC electric motor. Actual brake horsepower shall not exceed the rated horsepower at any time from open flow (0 vacuum) to ultimate vacuum (no flow). Belt drives shall not be permitted. Each pump shall be air-cooled and have absolutely no water requirements. Auxiliary heat exchangers shall not be permitted.  

D. Lubrication shall be provided by an integral, fully recirculating oil supply driven by differential pressure. Oil pumps, either direct or separately drive, shall not be permitted. Non-recirculating (once-through) or partial recirculating oil supply systems shall not be permitted. Each pump shall be equipped with an oil drain valve. Each pump shall be capable of operation with standard SAE 30 weight automotive grade oil. The separation system shall be capable of removing 99.9+ percent of all oil and smoke particles from the exhaust gas stream.  

E. Each pump shall have a built-in non-return valve mounted at the pump inlet, and each pump shall be equipped with three non-metallic, non-asbestos vanes, each having a minimum life of 30,000 hours. Each pump shall be equipped with a 5-micron inlet filter.  

F. All pumps shall be skid mounted in a vertical arrangement that allows for future expansion to a sextuplex (six pump) system. Pumps shall be connected to a common manifold and piped to an ASME coded vertical receiver. The receiver shall be equipped with a three-valve bypass arranged to permit draining and servicing the receiver without interruption of the vacuum system operation. The base shall be predrilled, and the manifold shall be prepiped to accept up to six vacuum pumps. The manifold shall include pre-installed ball-type isolation valves for all present and future pumps. Each vacuum pump shall be equipped with a check valve, a liquid filled vacuum gauge at the inlet of the pump a flex connector, and a bleed valve to permit venting of the inlet filter.  

G. Electrical controls shall be of the automatic alternating, lead/lag cascading type and shall consist of the following: (3) magnetic motor starters, each complete with a motor branch-circuit disconnect, and thermal, magnetic, and short-circuit protection; redundant, low voltage control transformers with fused primary and secondary; (3) digital hour meters with battery backup and remote indication; (3) hand-off-auto switches with pump run lights and remote indication when the switch is not in “auto”; pressure transducer to monitor and control the system operating vacuum level, with digital readout mounted on the enclosure door and remote indication; programmable controller with plug-in EEPROM module; reserve-pump-in-use alarm with red warning light, silencable 95dBA audible signal, and two additional sets of dry contacts for remote signaling; emergency shut-off switch; all housed in a NEMA 12 enclosure. The motor starters shall be mounted on a buss-bar type DIN rail for easy future expansion. The entire motor control center shall be configured for future expansion to an automatic alternating pentaplex or seuplex unit with the addition of only one hour meter, one H-O-A switch and one motor starter for each pump. No additional vacuum switches and no new EEPROM shall be required when expanding.
H. This control center shall alternate on a first-on, first-off basis, ensuring that no pump turns on and off successively without all other pumps in the system running first, and on a timed basis to ensure approximately equal run time for each pump. A time delay relay shall control all motors to ensure that no pump exceeds the NEMA recommended number of starts and stops per hour. All pumps will be set to turn on in a cascading (lead-lag) sequence, and will shut off when the vacuum level reaches the high set point, providing the time delay has elapsed. In the case of a power failure, the program shall be automatically downloaded from the EEPROM and the system shall restart automatically.

I. The vacuum system shall meet all requirements of the NFPA 99-1996 Standard for Health Care Facilities. The entire system shall be factory assembled by the vacuum pump manufacturer. The entire system shall be tested to insure that all performance specifications are met. Certified test data will be furnished at no charge.

J. The control center shall be capable of communicating to the building automation system (BAS) through either an open protocol or through hardwired points. At a minimum the following information shall be made available:

1. Each motor status
2. Each H-O-A “not in auto”
3. Vacuum level
4. Each motor run time
5. Reserve in use
6. System fault

PART 3 - EXECUTION

3.1 INSPECTION:

A. Examine areas and conditions under which Laboratory gas systems and equipment are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION OF BASIC IDENTIFICATION:

A. Install laboratory gas piping signs on piping in accordance with NFPA 99 requirements.

3.3 INSTALLATION OF LABORATORY GAS PIPING:

A. The Contractor shall furnish all labor, materials, equipment and services necessary to install a complete distribution system for oxygen, nitrous oxide, nitrogen, medical compressed air and vacuum and to perform all required "progresses" and final tests.

B. The entire laboratory gas system, or major sections of large systems, shall be completely installed and pressure tested prior to concealing within walls, ceiling or chases.

C. The Contractor shall be responsible for furnishing and installing all material and equipment listed in this specification and shown on the construction drawings, including piping, pipe fittings, pipe connectors and all related accessories.

D. The Contractor shall be responsible for final testing of all special piping systems as required by this specification and those required to comply with all local and state health and hospital codes and ordinances.

E. Laboratory gas materials and tools shall be kept separate from all other materials and tools.
F. Piping shall not be cleaned in the field, except where pipe ends have become contaminated. If required, wash in hot solution of sodium carbonate or trisodium phosphate mixed in proportion of 1-lb. to 3 gal. of water.

G. Scrubbing shall be employed where necessary to ensure complete cleaning. After washing, the material shall be rinsed thoroughly in clean hot water. After cleaning, particular care shall be exercised in the storage and handling of all pipe and fittings. Pipe and fittings shall be temporarily capped or plugged to prevent recontamination before final assembly. Tools used in cutting or reaming shall be kept free from oil and grease. Where such contamination has occurred, the items affected shall be rewashed and rinsed. Do not use steel wool to mechanically clean fittings or tubing. Wipe joints with a clean white cloth prior to joining piping. During brazing of Laboratory gas systems the piping shall be continuously purged with dry nitrogen to avoid oxidation of the inside of the tubing. Braze piping within one hour of being mechanically cleaned.

H. Braze piping joints and connections unless otherwise indicated. Do not use flux.

I. Protect buried gas piping against freezing and corrosion with underground piping insulation and corrosion-protective coating. Underground piping shall be installed in a continuous enclosure. The enclosure to be split or otherwise to provide access to joints for testing. Piping shall be below frost line or minimum 36inch bury. Provide continuous tape marker immediately above buried pipe.

J. After installation of piping, but prior to installation of outlet valves, blow lines clear with Grade "D" oil-free dry air or nitrogen.

K. Exhaust piping from duplex vacuum pumps shall be combined into a pipe header with sound dampening muffler exhaust pipe extending either through the roof or terminating through the wall at least ten (10) feet from any door, window or other opening in the building and at least 20 feet above the ground. Provide end of exhaust pipe with bird screen and end turned down or with rain cap. Pipe header shall have 10inch long drip leg with valve and drain pipe to indirect connection at floor drain pipe sizing per plans.

L. Laboratory gas piping systems shall not be used as a grounding electrode.

M. The air intake to Air Compressors shall be located outdoors above roof level a minimum distance of 10 feet from any door, window, intake, or opening in the building; a minimum distance of 20 feet above the ground; and a minimum distance of 25 feet from exhaust outlets of ventilating systems, combustion equipment stacks, medical-surgical vacuum systems, plumbing vent stacks, or from areas which may collect vehicular exhaust or other noxious fumes.

3.4 INSTALLATION OF SUPPORTS AND ANCHORS:

A. Install supports and anchors, in accordance with Division 22, "Supports and Anchors".

3.5 INSTALLATION OF VALVES:

A. Shutoff Valves: Provide shutoff valves where indicated, and in accordance with NFPA 99.

B. Valve Boxes: Where indicated, provide valve boxes with frangible or removable windows, large enough to permit manual operation of valves, and labeled in accordance with NFPA 99.

C. Main Shutoff Valves: Where indicated, provide shutoff valve downstream of source valve on each main supply line, locate to be accessible in emergency.
3.6 INSTALLATION OF EQUIPMENT AND ACCESSORIES:

A. Install Laboratory gas equipment and accessories where indicated, in accordance with applicable NFPA standards, with equipment manufacturer's written instructions, and with recognized industry practices, to ensure that laboratory gas equipment and accessories comply with requirements and serve intended purposes.

B. Coordinate with other work including plumbing, as necessary to interface installation of laboratory gas piping and equipment with other work.

C. Air Compressor Intakes: Install air compressor intakes and vacuum pump exhausts as indicated, and in manner to ensure that vacuum pump exhaust will not contaminate air compressor intake nor HVAC ventilation system.

D. Support: Install equipment on 4 inches high reinforced concrete pads, 4 inches larger on each side than equipment base. Cast anchor bolt inserts into pad.

E. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.
   1. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division-16 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.

F. Valve Boxes shall be installed with bottom of lowest unit at 60 inches above floor. Do not exceed 6'-6" to highest valve handle.

G. Ceiling dispensing boxes and reels and ceiling mounted service columns shall be provided by the Mechanical Contractor and installed by the General Contractor. Mechanical Contractor shall make all laboratory gas and vacuum piping connections. Electrical Contractor shall install all wiring and make electrical connections.

3.7 EQUIPMENT CONNECTIONS:

A. General: Connect laboratory gas systems to mechanical equipment as indicated, and comply with equipment manufacturer's instructions where not otherwise indicated.

3.8 FIELD QUALITY CONTROL:

A. Test laboratory gas piping, including pressure, cross connection, and final testing in accordance with NFPA 99. Indicate in writing to Owner that required tests have been successfully conducted and permanent records of tests maintained.

B. Test laboratory gas alarms for proper operation at high pressure, low pressure, and gas supply status.

3.9 TESTS FOR LABORATORY GAS PIPING:

A. Pressure test in strict accordance with NFPA 99 will be required. Specific attention is directed to absolute prohibition of the use of oil pumped compressed air or oil pumped nitrogen and the prohibition of the use of hydrostatic test. Testing medium shall be WATER PUMPED COMPRESSED AIR or VAPOR PUMPED NITROGEN. Cylinder shall be so labeled.

B. A 24-hour standing pressure test with oil free (water pumped) nitrogen or air at one and one-half times maximum working pressure, but in no case less than 150 psi., shall be made prior to "trimming"
laboratory gas outlet station valves to check the completeness of previous joint tests. After trimming out the lab gas outlet stations, the system shall be tested for 24 hours at 20 percent above working pressure. After completion of the final standing pressure test, the system shall be thoroughly flushed with the gas to be used in the system to assure the removal of all nitrogen or air.

C. After completion of final testing and flushing of the piping system, the lab gas system shall be tested in accordance with NFPA 99 by the laboratory gas equipment supplier, in the presence of an authorized representative of the Owner. The lab gas equipment supplier shall furnish written certification to the Owner that the system has been so tested and is free of crossed-connections. Cost of gases required for testing shall be borne by the Mechanical Contractor. Further, the cost of subsequent tests required to re-check initial errors shall be the responsibility of this contractor.

D. When all lab gas piping systems have been tested as specified above, the source of test gas shall be disconnected and the proper gas source of supply connect as specified above, the source of test gas shall be disconnected and the proper gas source of supply connected to each respective system. Following this connection and pressurization, all outlets shall be opened in a progressive order, starting nearest the source and completing the process of purge flushing at the outlet farthest from the source. Gas shall be permitted to flow from each outlet until each system is purged of test gas used during previous tests.

PART 4 - EQUIPMENT

4.1 EQUIPMENT START-UP:

A. Vacuum Pumps:
   1. Provide factory startup of all Laboratory gas equipment. Provide startup report in O & M manual and submit to Commissioning Agent.
   2. Provide 20 hours of factory training
   3. Warranty the equipment for 2 years from UCB acceptance.

B. Air compressors:
   1. Provide factory startup of all Laboratory gas equipment. Provide startup report in O & M manual and submit to Commissioning Agent.
   2. Provide 10 hours of factory training
   3. Warranty the equipment for 2 years from UCB acceptance.

END OF SECTION 22 62 13
PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. This section specifies pure water system components, including pure water piping and fittings, valves, piping specialties, and pumps.

B. Related Sections: Refer to other Division 22 sections for supports and anchors, mechanical identification, mechanical insulation, and fire barrier seals.

C. Water distribution systems covered by this section include the following:
   1. RO/DI water systems.

1.2 SUBMITTALS:

A. Refer to Division 1 and Basic Mechanical Requirements for administrative and procedural requirements for submittals.

B. Provide complete submittal data for the following:
   1. Piping, including type and joining process.
   2. Valves
   3. Piping specialties, including meters, gauges, and point of use faucets.
   4. Pumps.
   5. Storage Tanks.

C. Certification of compliance with ASME, UL, and 3-A (sanitary) fabrication requirements.

D. Certification if individuals performing fusion techniques for polypropylene, or PVDF.

E. Test Reports, including piping, weld and tank testing.

F. Maintenance data, as required by Division 1 and Basic Mechanical Requirements.

G. Refer to Division 26 sections for the following work; not work of this section:
   1. Power supply wiring from power source to power connection on pumps. Include starters, disconnects, and required electrical devices, except where specified as furnished, or factory-installed, by manufacturer.
   2. Interlock wiring between pumps; and between pumps and field-installed control devices.
      a. Interlock wiring specified as factory-installed is work of this section.

H. Provide the following electrical work as work of this section, complying with requirements of Division 26 sections:
   1. Control wiring between field-installed controls, indicating devices, and pump control panels.
1.3 QUALITY ASSURANCE:

A. Comply with the provisions of the latest edition of the International Plumbing Code.

B. Manufacturer Qualifications: Firms regularly engaged in the manufacture of pure water distribution system components, whose products have been in satisfactory use and similar service for not less than (5) years.

C. Installer Qualifications: All pure water distribution system installation work shall be performed by firms regularly engaged in the installation of pure water distribution systems, whose work has been in satisfactory operation and service for a minimum of (5) years.

D. Comply with the provisions of ASME, UL, and 3-A as they relate to the material and methods specified herein.

E. Each individual contractor installing PP and PVDF shall be trained by the manufacturer’s representative for certification card.

F. Contractors installing PP or PVDF by way of butt or socket fusion shall be required, upon request by owner or engineer to cut out fitting to show installation is in compliance with manufacturer’s requirements. Excessive beads of molten plastic will warrant the need for fitting replacement throughout.

1.4 DELIVERY, STORAGE AND HANDLING:

A. Deliver and store piping with plastic end-cap protectors to prevent pipe-end damage and to eliminate dirt and moisture from entering interior of pipe/tubing.

B. All pipe fittings and valves shall be packaged, delivered, and stored in sealed polyethylene bags, individually-wrapped.

C. Store pure water system piping and equipment indoors and protect from weather, sunlight, and construction traffic.

1.5 WARRANTY:

A. Provide 3 year parts and labor warranty for pure water system.

PART 2 - PRODUCTS:

2.1 PURE WATER PIPE AND PIPE FITTINGS:

A. Piping Materials: Provide pipe and tubing type, pressure and temperature ratings, capacities, joint type, grade, size and weight indicated for pure water service.

B. Pipe/Tubing Fittings: Provide factory-fabricated fittings of type, materials, grade, class, and pressure rating indicated. Provide sizes and types matching pipe, tube, valve or equipment connection in each case. Threaded pipe connections are not acceptable.

C. Manufacturers: Subject to compliance with requirements, provide pure water piping and fittings of one of the following:

1. Thermoplastic (PP and PVDF) Piping:
2. Stainless Steel Piping:
   a. Tri-Clover, Inc.
   b. Waukesha Fluid Handling.


E. Polyvinylidene Fluoride (PVDF) Piping and Fittings: Schedule 80 I.P.S. unpigmented natural Polyvinylidene Fluoride pipe, conforming to ASTM D-1785, with matching fittings and mechanical joints, conforming to ASTM D-2467. Piping shall have a 25/50 flame and smoke spread rating for installation in a return air plenum.

F. Stainless Steel Tubing: Type 316L stainless steel tubing with sanitary clamp connections and butt-weld fittings. Interior finish on tubing and fittings shall be 20-microinch roughness average (Ra) value, plus electropolish. Sanitary clamp assembly shall consist of type 304 stainless clamp and Buna N gasket.

2.2 VALVES:

A. General: Provide valves of size and type to match the pure water piping system, compatible with the application.

B. Manufacturers: Subject to compliance with requirements, provide pure water valves manufactured by the following:

1. Thermoplastic Ball and Check Valves:
   a. Orion
   b. R & G Sloane Manufacturing Co.
   c. Enfield Industrial Corp.
   d. Hayward
   e. Plast-O-Matic Valves, Inc.
   f. Asahi/America

2. Stainless Steel Ball Valves:
   a. Tri-Clover, Inc.
   b. Waukesha Fluid Handling

3. Thermoplastic Butterfly Valves
   a. R & G Sloane Manufacturing Co.
   b. Hayward
   c. Asahi/America

4. Stainless Steel Butterfly Valves:
a. Tri-Clover, Inc.  
b. Waukesha Fluid Handling

5. Thermoplastic Diaphragm Valves:
   a. Asahi/America  
   b. Gemu Valve

6. Stainless Steel Diaphragm Valves:
   a. Saunders Valve, Inc.

C. Thermoplastic Ball Valves: Ball valves shall be full-ported, true union valves constructed of Polypropylene/PVDF, with quarter-turn lever handle that indicates position of valve. Valve shall be equipped with Viton O-Ring union seals and Teflon ball seals.

D. Stainless Steel Ball Valves: Ball Valves shall be full-ported, three-piece valves with threaded connections, with type 316 stainless steel body and ball, and TFE seats and seals. Tri-Clover, Inc. Model "BV" or equivalent.

E. Thermoplastic Butterfly Valves: Solid PVC molded body, with glass-filled polypropylene disc and EPDM O-rings and valve liner. Valve shaft shall be stainless steel, with a quarter-turn spring-action lever handle. 150 psi rated at 100 degrees F. Valve shall be wafer-style, for ANSI full-faced flange connection.

F. Stainless Steel Butterfly Valves: Type 316 stainless steel body with sanitary clamp connections, type 316 stainless steel disc, EPDM seat, and type 304 stainless steel handle assembly and body bolt assembly. Pressure rated to 140 psi at 200 degrees F. Tri-Clover Inc. model B51 or equivalent.

G. Thermoplastic Diaphragm Valves: Diaphragm valves shall be constructed with Polypropylene/PVDF bonnet, and neoprene diaphragm. Body shall have true union ends, and valve shall be equipped with position indicator and adjustable travel stop.

ASAHI/America Type 72-true union or equivalent.

H. Stainless Steel Diaphragm Valves: Diaphragm valves shall be constructed with type 316L stainless steel, with 180 grit/electro-polish interior finish, sanitary clamp connections, and nickel-plated bonnet. Diaphragm shall be Black Ethylene Propylene, FDA-approved. Valve shall be equipped with handwheel operator and valve position indicator.

Saunders Valve Inc. Model 70066-12-EB.

I. Thermoplastic Ball Check Valves: Ball check valves shall be true-union style, with body constructed of PVC/CPVC. Valve shall be provided with glass-filled polypropylene ball and EPDM ball and O-ring seals. Valve shall be pressure-rated to 100 psi at 100 degrees F (PVC) or 100 psi at 130 degrees F (CPVC).

2.3 PIPING SPECIALTIES:

A. Sight Glass - Thermoplastic: Single cylinder wall flow indicator with clear acrylic cylinder and Polypropylene/PVDF ends and threaded connections. Seals shall be [Buna-N/Viton]. Sight Glass shall be Plast-O-Matic model "GX" or equivalent.
B. Pressure Gauge with Diaphragm Seal (Thermoplastic): 2inch diameter dial-type pressure gauge with 3percent accuracy and a 0-100 psig pressure range, with diaphragm seal gauge guard, constructed of Polypropylene/PVDF, with Teflon diaphragm seal. Upper housing cavity shall be filled with FDA-approved refined mineral oil. Plast-O-Matic model GGMT-100-XX or equivalent.

C. Pressure Gauge (Stainless Steel): 3-1/2inch diameter dial-type diaphragm pressure gauge, with type 316 stainless steel diaphragm, bourdon tube and socket. Gauge shall have 0-100 psig range, and 1-1/2inch sanitary clamp connection. Weksler Instruments model 3A43F-A15 or equivalent.

D. Temperature Gauge (Stainless Steel): 3inch diameter dial-type sanitary bi-metal thermometer, with all-stainless steel construction, 20-240-degrees F. temperature range and 4inch stem length. Provide with each thermometer, type 316L stainless steel thermowell, with 1-1/2inch sanitary clamp connection. Weksler Instruments model 3S04-9 thermometer with model D8J4 thermowell or equivalent.

E. Point-of-Use Laboratory Faucet (where not specified with lab casework): LF-1 Rigid gooseneck faucet, deck-mounted, constructed of PVDF/polypropylene, with needle point valve, serrated hose nozzle, and 3/8inch NPT female inlet. Chicago Faucet model 869-B, or equivalent.


G. Thermoplastic Storage Tanks: Provide vertical cylindrical pure water storage tanks of sizes and capacities indicated, manufactured of materials and equipped with accessories as listed below and as shown on the drawings.

1. Polyethylene 5-1,000 gallon sizes: High density polyethylene 1/4 inch (55-360 gallons), 5/16 inch (500 gallons), 7/16 inch (1,000 gallons) thick walls.

2. Polypropylene 5-360 gallon sizes unpigmented natural polypropylene with 1/4 inch (55-360 gallons) thick walls.

3. Tank Accessories:
   a. Cover
   b. Volume indication calibrated in gallons and litres
   c. Bulkhead type fittings.
   d. Welded Steel Floorstand.

4. Manufacturer's: Subject to compliance with requirements, provide pure water storage tanks manufactured by the following:
   a. Nalgene, Inc.
   b. Snyder Industries, Inc.

2.4 PUMPS:

A. General: Provide factory-tested pumps, thoroughly cleaned, and painted with one coat of machinery enamel prior to shipment. Type, size, and capacity of each pump is listed in pump schedule. Provide pumps of same type by same manufacturer.
B. Pump motor shall be sized so as not to be overloaded at any point along impeller curve for specified performance.

C. All pump couplers shall be suitable for both constant speed and variable speed operation.

D. Pure Water Pumps: Provide pure water pumps as indicated and of type and capacities as scheduled.
   1. Type: Horizontal, base-mounted, single stage end-suction, designed for 175 psi working pressure.
   2. Body: Type 316 stainless steel, flanged suction and discharge.
   3. Impeller: Type 316 stainless steel, with type 316 stainless key, washer and cap screw.
   4. Shaft: Steel ground and polished.
   5. Seal: Buna-N bellows and O-ring, with Carbon-Ceramic Faces.
   7. Manufacturer: Subject to compliance with requirements, provide pure water pumps manufactured by the following:
      a. Grundfos

PART 3 - EXECUTION

3.1 EXAMINATION:
   A. Verify all dimensions by field measurements. Verify that all pure water distribution systems may be installed in accordance with pertinent codes and regulations, original design and the referenced standards.
   B. Examine rough-in requirements for equipment having pure water connections to verify actual locations of piping connections prior to installation.
   C. Do not proceed until unsatisfactory conditions have been corrected.

3.2 PIPING INSTALLATION:
   A. Application: Utilize polypropylene piping unless routing through a return air plenum, in which case shall be PVDF.
   B. General: Install pipes and fittings in accordance with manufacturer's recommended installation procedures which will achieve permanently-leakproof piping systems, capable of performing indicated service without piping failure. Install each run with minimum joints and couplings, but with adequate and accessible unions for disassembly and maintenance/replacement of valves and equipment. Reduce sizes (where indicated) by use of reducing fittings. Align piping accurately at connections, within 1/16inch misalignment tolerance.
   1. System Dead-Leg Requirements: Install pure water piping to minimize dead-leg dimensions, as measured from branch tee to point-of-use valves.
a. Maximum system dead-leg shall be 5 branch pipe diameters in length.

2. Electrical Equipment Spaces: Do not run piping through transformer vaults and other electrical or electronic equipment spaces and enclosures.

3. Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate the general location and arrangement of piping systems. Locations and arrangements of piping take into consideration pipe sizing and friction loss, expansion, pump sizing, and other design considerations. So far as practical, install piping as indicated.

4. Use fittings for all changes in direction and all branch connections.

5. Install piping at right angles or parallel to building walls. Diagonal runs are not permitted, unless expressly indicated.

6. Conceal all pipe installations in walls, pipe chases, utility spaces, above ceilings, below grade or floors, unless indicated to be exposed to view.

7. Install piping tight to slabs, beams, joists, columns, walls, and other permanent elements of the building. Provide space to permit insulation applications, with 1” clearance outside the insulation. Allow sufficient space above removable ceiling panels to allow for panel removal.

8. Install piping free of sags or bends.

9. Fire and Smoke Wall Penetrations: Provide UL listed system for all pipes which pass through fire and smoke rated walls, partitions, ceilings, and floors, maintain the fire and smoke rated integrity.

10. Coordinate foundation and all other structural penetrations with structural engineer.

3.3 INSTALLATION OF HANGERS AND SUPPORTS:

A. Install hangers, supports, cushion clamps and attachments to support piping properly from building structure; comply with MSS SP-69 and SP-89. Arrange for grouping of parallel runs of horizontal piping to be supported together on field fabricated, heavy-duty trapeze hangers where possible. Install supports with maximum spacings complying with MSS SP-69 for stainless steel piping. Where piping of various sizes is supported together by trapeze hangers, space hangers for smallest pipe size or install intermediate supports for smaller diameter pipe. Do not use wire or perforated metal to support piping, and do not support piping from other piping or ductwork. Cushion clamps shall be used to avoid over torque of clamp on pipe.

B. Support spacing for Thermoplastic Piping: Install pipe supports with maximum spacing as outlined below:

1. Polypropylene (PP), PVDF Piping, Schedule 80:

<table>
<thead>
<tr>
<th>Pipe Size</th>
<th>Maximum Support Spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>½&quot;</td>
<td>3'-6&quot;</td>
</tr>
<tr>
<td>¾&quot;</td>
<td>3'-6&quot;</td>
</tr>
<tr>
<td>1&quot;</td>
<td>4'-0&quot;</td>
</tr>
<tr>
<td>1-1/4&quot;</td>
<td>4'-6&quot;</td>
</tr>
</tbody>
</table>
C. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers and other accessories.

D. Install hangers and supports to allow controlled movement of piping systems, to permit freedom of movement between pipe anchors, to facilitate action of expansion loops, expansion bends and similar units and within 1 foot-0 inches of each horizontal elbow.

E. Load Distribution: Install hangers and supports so that piping live and dead loading and stresses from movement will not be transmitted to connected equipment.

F. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes, and so that maximum pipe deflections allowed by ANSI B31.9 Building Services Piping Code is not exceeded.

G. Use hangers which are vertically adjustable 1-1/2 inch (38.1 mm) minimum after piping is erected.

H. Where several pipes can be installed in parallel and at same elevation, provide trapeze hangers.

I. Where practical, support riser piping independently of connected horizontal piping.

J. Each pipe drop to equipment shall be adequately supported. All supporting lugs or guides shall be securely anchored to the building structure.

K. Install all couplings with torque wrench, torqued to inch pounds as specified by the manufacturer.

3.4 VALVE INSTALLATION:

A. Examination:

1. Install valves in accordance with manufacturers instructions.

2. Examine valve interior through the end ports, for cleanliness, freedom from foreign matter and corrosion. Remove special packing materials, such as blocks used which prevents disc movement during shipping and handling.

3. Actuate valve through an open-close and close-open cycle. Examine functionally significant features, such as guides and seats made accessible by such actuation. Following examination, return the valve closure member to the position in which it was shipped.

4. Examine mating flange faces for conditions which might cause leakage. Check bolting for proper size, length, and material. Check gasket material for proper size and material, and for freedom from defects and damage.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves and unions for each fixture and item of equipment in a manner to allow equipment removal without system shut-down. Unions are not required on flanged devices.
D. Ball valves and diaphragm valves shall be installed with the stem in the upright position. The handle of quarter turn valves shall open in the direction of flow. Butterfly valves shall be installed with the stem in the horizontal position.

E. Installation of Check Valves: Install for proper direction of flow as follows:
   1. Ball Check Valves: Install in horizontal position with attention paid to flow arrow imprinted on check valve.

F. As soon as work has been completed, conduct preliminary tests to ascertain compliance with specified requirements. Make repairs or replacements as required.

3.5 INSTALLATION OF STORAGE TANKS:

A. General: Install pure water storage tanks as indicated, in accordance with manufacturer's installation instructions and in compliance with applicable codes.

B. Support: Set units on concrete pads, level and plumb.

C. Connections: Make connections between storage tanks and pure water piping with shutoff valves and unions or flanges; as indicated.

D. Flushing: Flush storage tanks upon completion of installation in accordance with manufacturer's instructions.

3.6 INSTALLATION OF PUMPS:

A. General: Install pumps where indicated, in accordance with manufacturer's published installation instructions, complying with recognized industry practices to ensure that pumps comply with requirements and serve intended purposes.

B. Access: Provide access space around pumps for service as indicated, but in no case less than that recommended by manufacturer.

C. Support: Install base-mounted pumps on minimum of 4 inches high concrete base equal or greater than 3 times total weight of pump and motor, with anchor bolts poured in place. Set and level pump, grout under pump base with non-shrink grout.

   1. Install in-line pumps, supported independent of piping system.

D. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.

   1. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division 26 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.

3.7 PIPING TESTS:

A. Give a minimum of twenty-four hours notice to Architect/Owner/Engineer of dates when acceptance test will be conducted. Conduct tests as specified for each system in presence of representative of agency having jurisdiction or his representative. Submit three (3) copies of successful tests to the Engineer for his review. Report shall state system tested and date of successful test.
B. All costs involved in these tests shall be borne by Contractor.

C. System Tests

1. Hydrostatic Test: The test shall be accomplished by hand pumping the system to the specified water pressure, and maintaining that pressure until the entire system has been inspected for leaks, but in no case for a time period of less than four hours.

   a. Pure water systems: 100 psig or 150 percent of system pressure, whichever is greater.

3.8 FIELD QUALITY CONTROL & TESTING:

A. Spot Joint Inspectors: Contractors installing PP or PVDF by way of butt or socket fusion shall be required, upon request by owner or engineer to cut out fitting to show installation is in compliance with manufacturer’s requirements. Excessive beads of molten plastic will warrant the need for fitting replacement throughout.

B. Preparation for testing: Prepare pure water piping in accordance with ASME B 31.9 and as follows:

   1. Leave joints including welds exposed for examination during the test.
   2. Flush system with clean water.
   3. Isolate equipment that is not to be subjected to the test pressure from the piping. If a valve is used to isolate the equipment, its closure shall be capable of sealing against the test pressure without damage to the valve. Flanged joints at which blinds are inserted to isolate equipment need not be tested.
   4. Install relief valve set at a pressure not more than 1/3 higher than the test pressure, to protect against damage by expansion of liquid or other source of overpressure during the test.

3.9 ADJUSTING AND CLEANING:

A. General: Clean exterior surfaces of installed piping systems of superfluous materials. Flush out piping systems with clean water before proceeding with required tests. Inspect each run of each system for completion of joints, supports and accessory items.

B. Clean and flush pure water piping systems and prepare system for final cleaning.

C. Sterilized system, submit type-written test report indicating water quality test results meet or exceed purity levels.

PART 4 - EQUIPMENT

4.1 EQUIPMENT START-UP:

A. Provide factory startup of all Laboratory pure water equipment. Provide startup report in O & M manual and submit to commissioning agent.

B. Provide 40 hours of factory training to the owner.
PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A.Extent of firestopping required by this section is indicated on the drawings and by the requirements of this section.

B. Types of firestopping systems specified in this section include:

1. Bare metal pipe
2. Insulated metal pipe
3. Plastic piping
4. Metal conduit
5. Metal duct

1.2 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in the manufacturing of firestopping systems for mechanical/electrical penetrations, whose products have been in satisfactory use for not less than 5 years, with published application data for all types of penetrations to be encountered on this job, and with local representation capable of providing training and technical assistance at the job site.

B. Installer's Qualifications: Personnel installing firestopping systems shall have been specifically trained in the application of the materials to comply with the listing of the tested assembly.

C. Codes and Standards: Comply with the applicable codes pertaining to firestopping. Firestopping systems shall be tested and listed in accordance with the following:

1. Underwriter's Laboratory:
   a. UL 1479 test method for fire tests of through-penetration firestops.
   b. UL Fire Resistance Directory


1.3 SUBMITTALS:

A. Product Data: Manufacturer's specifications and technical data including the following:

1. Detailed specification of construction and fabrication.

2. Manufacturer's installation instructions.

B. Shop Drawings: Indicate dimensions, description of materials and finishes, general construction, specific modifications, component connections, anchorage methods, hardware and installation procedures, plus the following specific requirements:

1. Details of each proposed assembly, for all types of fire rated construction and penetrating items encountered, identifying intended products and applicable UL System Number, or UL classified devices.
2. Manufacture or manufacturer's representative shall provide qualified engineering judgments and drawings relating to non-standard applications as needed.

1.4 DELIVERY, STORAGE AND HANDLING:

A. Packing and Shipping:
   1. Deliver products in original, unopened packaging with legible manufacturer's identification.
   2. Coordinate delivery with scheduled installation date, allow minimum storage at site.

B. Storage and Protection: Store materials in a clean, dry ventilated location. Protect from soiling, abuse, moisture and freezing when required. Follow manufacturer's instructions.

1.5 PROJECT CONDITIONS:

A. Existing Conditions:
   1. Verify existing conditions and substrates before starting work. Correct unsatisfactory conditions before proceeding.
   2. Proceed with installation only after penetrations of the substrate and supporting brackets have been installed.

B. Environmental Requirements:
   1. Furnish adequate ventilation if using solvent.
   2. Furnish forced air ventilation during installation if required by manufacturer.
   3. Keep flammable materials away from sparks or flame.
   4. Provide masking and drop cloths to prevent contamination of adjacent surfaces by firestopping materials.
   5. Comply with manufacturing recommendations for temperature and humidity conditions before, during and after installation of firestopping.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Subject to compliance with the requirements of this specification, provide products by one of the following:
   1. 3M, Fire Protection Products – Obtain UCB approval
   2. Bio-Fireshield
   3. General Electric Company
   4. Hilti
   5. TREMCO Construction Products

2.2 GENERAL:

A. Provide fire stop systems listed in the UL Fire Resistance Directory. Provide systems with fire resistance "F" ratings equal to the fire resistance rating of the wall or floor assembly for all penetrations.
In addition, provide systems with a "T" rating equal to the fire resistance rating of the wall or floor assembly in the following applications.

1. Penetrating items larger than 4" diameter or 16 square inches in corridor walls.
2. Penetrating items larger than 4" diameter or 16 square inches when they are below the ceiling in any fire resistive wall.
3. Any floor penetrations not within a wall or chase.
4. Any floor penetrations larger than 4" in diameter or 16 square inches.

2.3 ACCESSORIES:
A. Provide forming and damming materials and sleeves as required by the firestopping system installation instructions.

PART 3 - EXECUTION

3.1 GENERAL:
A. Review all project drawings and existing conditions to determine location, rating, and construction of all fire resistive construction.
B. Coordinate location of penetrations to allow for the maximum and minimum annular space around the penetrating item. Allow a minimum of 1” undisturbed building material between penetrations, or provide a firestopping system listed for multiple penetrations. Penetrating items shall be centered in hole as much as practical, unless firestopping system is listed for point contact between the wall/floor assembly and the penetrating item.
C. Neatly form, saw cut, hole saw or core drill openings. Size openings to conform with the maximum and minimum annular space requirements of the firestopping system.

3.2 APPLICATION:
A. The Contractor shall determine the most appropriate firestopping system which complies with these specifications.
B. All insulation shall be continued through the penetration. Provide intumescent caulk or collar firestopping systems. Where the insulation thickness specified in Section 15250 exceeds the allowable insulation thickness for the firestopping system, reduce the insulation thickness 6” on either side of the penetration. Do not reduce insulation to less than 50% of the specified thickness.
C. Provide collar type firestopping systems where shown on drawings, and for hot piping systems at penetrations where significant thermal movement can be expected, such as near expansion compensation loops or joints.
D. Provide a firestopping system for ducts penetrating fire resistive construction without fire or fire/smoke dampers.
   1. Do not provide firestopping between fire or fire/smoke damper sleeves and the opening.
E. Anchor wiring not within conduit on each side of a penetration to prevent it from being pulled out of the firestopping system.
F. See Section 22 14 23 23 for sleeves. The use of sleeves may affect the "T" rating of the firestopping system. Coordinate use of sleeves with firestopping.

END OF SECTION 23 04 13
PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

A. All drawings associated with the entire project, including general provisions of the Contract, including The General Conditions of the Contract for Construction, General and Supplementary Conditions and Division-1 Conditions specification sections shall apply to the Division 23 specifications and drawings. The Contractor shall be responsible for reviewing and becoming familiar with the aforementioned and all other Contract Documents associated with the project.

B. Related Sections: Refer to all sections in Division 23. Refer to Division 26 specification sections and Division 26 drawings.

C. Where contradictions occur between this section and Division 1, the more stringent requirement shall apply.

D. Contractor shall be defined as any and all entities involved with the construction of the project.

1.2 SUMMARY:

A. This Section specifies the basic requirements for mechanical installations and includes requirements common to more than one section of Division 23. It expands and supplements the requirements specified in Division 1.

1.3 MECHANICAL INSTALLATIONS:

A. The Contract Documents are diagrammatic, showing certain physical relationships which must be established within the mechanical work and its interface with all other work. Such establishment is the exclusive responsibility of the Contractor. Drawings shall not be scaled for the purpose of establishing material quantities.

B. Drawings and specifications are complementary. Whatever is called for in either is binding as though called for in both. Report any discrepancies to the Engineer and obtain written instructions before proceeding. Where any contradictions occur between the specifications and the drawings the more stringent requirement shall apply. The contractor shall include pricing for the more stringent and expensive requirements.

C. Drawings shall not be scaled for rough-in measurements or used as shop drawings. Where drawings are required for these purposes or have to be made from field measurement, Contractor shall take the necessary measurements and prepare the drawings.

D. The exact location for some items in this specification may not be shown on the drawings. The location of such items may be established by the Engineer during the progress of the work.

E. The contract documents indicate required size and points of terminations of pipes, and suggest proper routes to conform to structure, avoid obstructions and preserve clearances. It is not intended that drawings indicate necessary offsets. The contractor shall make the installation in such a manner as to conform to the structure, avoid obstructions, preserve headroom and keep openings and passageways clear, without further instructions or costs to the Owner. All equipment shall be installed so access is maintained for serviceability.
F. Before any work is installed, determine that equipment will properly fit the space; that required piping grades can be maintained and that ductwork can be run as intended without interferences between systems, structural elements or work of other trades.

G. Verify all dimensions by field measurements.

H. Coordinate installation in chases, slots and openings with all other building components to allow for proper mechanical installations.

I. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the work. Give particular attention to large equipment requiring positioning prior to closing-in the building.

J. Where mounting heights are not detailed or dimensioned, install mechanical services and overhead equipment to provide the maximum headroom possible.

K. Install mechanical equipment to facilitate maintenance and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.

L. Make allowance for expansion and contraction for all building components and piping systems that are subject to such.

M. The ceiling space shall not be “layered”. It is the contractor’s responsibility to offset and system as required to allow installation within the identified ceiling cavity. The contractor shall include labor and material in the base bid to accommodate such offsets.

N. In general, all “static” piping systems shall be routed as high as possible, i.e. fire protection systems. Keep all equipment in accessible areas such as corridors and coordinate with systems and equipment from other sections.

O. The Contractor shall provide all labor and material necessary but not limited to the starting/stopping of all mechanical equipment, opening/closing of all valves, draining/refilling all mechanical systems and operating/verifying the operation of all mechanical systems controls as required to accomplish all work necessary to meet construction document requirements. Contractor shall submit records of such activities to engineer and include in the O & M manuals.

P. All work shall operate in accordance with the Vibration, Siesmic and Sound Control specification under all conditions of load.

Q. Sound or vibration conditions not in accordance with the Vibration, Seismic and Sound Section and considered objectionable by the University shall be corrected in a manner approved by the project Architect under the work of Division 22/23.

1.4 COORDINATION:

A. Work out all installation conditions in advance of installation. The Contractor shall be responsible for preparing coordination drawings, showing all work, in all areas. The Contractor shall be responsible for providing all labor and material, including but not limited to all fittings, isolation valves, offsets, hangers, control devices, etc., necessary to overcome congested conditions at no increase in contact sum. The Contractors base bid shall include any and all time and manpower necessary to develop such coordination efforts and drawings. Increases to contract sum or schedule shall not be considered for such effort.
B. Provide proper documentation of equipment, product data and shop drawings to all entities involved in the project. Coordination shall include, but not be limited to the following:

1. Fire Protection and Fire Alarm Contractor shall provide shop drawings to all other Contractors.

2. Automatic Temperature Controls, Building Management and Testing, Adjusting and Balancing Contractors shall be provided with equipment product data and shop drawings from other Contractors and shall furnish the same information involving control devices to the appropriate Contractor.

C. Coordination Drawings:

1. Coordination drawings shall be prepared by the Contractor for his utilization and are his responsibility to assure systems will be installed in a manner to allow all systems to function properly.

2. Submit drawings for all areas, pay special attention to those places where clearances are limited, where space problems exist, for places where several elements of work (or combinations of mechanical and other work) must be located with precision in order to fit into available space, where sequencing is of importance to the efficient flow of work and as specified, and required.

3. Coordination drawings are informational submittals. Submit coordination drawings to Engineer for information only to document proper coordination of all portions of work and that coordination issues have been identified and resolved prior to submitting to the Engineer and prior to commencing construction in each affected area. **The review of the coordination drawings by the Engineer does not constitute a relief of responsibility of the Contractor or a change to the contract documents. The Contractor shall have sole responsibility in developing a fully coordinated and integrated ceiling cavity.**

4. The Contractor shall take the lead in coordinating and drawing Electrical and other Division 21, 22 & 23 components such as fire protection, plumbing, piping, sheet metal, etc. Where appropriate, the Contractor shall include medical gas, conduit, cable trays, pneumatic tube and any other system which may occupy the ceiling cavity.

5. Clearly indicate solutions to space problems. Identification of space problems without solutions is not acceptable. Only areas clearly identified will be reviewed.

6. All coordination drawings shall be 3D, with provision for collision check. The contractor is responsible for obtaining the architectural and structural files in 3D. All 3D drawing development, collision check, coordination, etc. shall be included as part of the Contractors base bid.

7. Prepare 3D Coordination Drawings (Shop Drawings) at a suitable scale, showing the required dimensions. In addition to the mentioned areas above, also submit the following:

   a. All mechanical equipment rooms such as fan rooms, boiler rooms, fire protection system rooms, etc. (1/4”=1’-0” scale).

   b. All building floor plans (1/8”=1’-0” scale). Include all shafts with clearances.

   c. Air handling unit, etc. main duct connections and transitions in ceiling space and to shafts or horizontal ducts. (1/4”=1’-0”).
d. Required access for all equipment requiring code or maintenance access.

e. All sections and elevations necessary for clarification.

f. Indicate all seismic restraint and support systems to be used for all mechanical equipment throughout the project.

g. Indicate locations of ceiling and wall access panels and other necessary access space.

h. Indicate duct and pipe elevations. Indicate clearances for installing and maintaining insulation.

i. Indicate access to isolation valves.

j. Indicate clearances for servicing and maintaining equipment, valve stem movement, and similar requirements.

k. Indicate movement and positioning of large equipment into the building during construction. Indicate pipe and duct size. Indicate equipment tags.

8. CADD Drawings: Electronic mechanical AutoCAD drawings are available for purchase by the Contractor from the Engineer. Contact Engineer for further information in acquiring CADD drawings. The Engineers Construction documents cannot be used directly for coordination drawings. They are for information and initial coordination only.

D. Utility Connections:

1. Coordinate connection of mechanical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies and controlling agencies. Provide required connection for each service.

2. The contract documents indicate the available information on existing utilities and services and on new services (if any) to be provided to the project by utility companies and agencies. Notify Engineer immediately if discrepancies are found.

3. Coordinate mechanical utility interruptions one week in advance with the Owner and the Utility Company. Plan work so that duration of the interruption is kept to a minimum.

1.5 COORDINATION WITH OTHER DIVISIONS:

A. General:

1. Coordinate all work to conform with the progress of the work of other trades.

2. Complete the entire installation as soon as the condition of the building will permit. No extras will be allowed for corrections of ill timed work, when such corrections are required for proper installation of other work.

B. Coordinate ceiling cavity space carefully with all trades. In the event of conflict, install mechanical and electrical systems within the cavity space allocation in the following order of priority:

1. Equipment and required clearances

2. Plumbing waste, cooling coil drain piping and roof drain mains and leaders.

3. Ductwork mains
4. Plumbing vent piping
5. Med gas/lab gas systems
6. Low pressure ductwork and air devices.
7. Electrical and communication conduits, raceways and cable tray.
8. Domestic hot and cold water
9. Hydronic piping
10. Fire sprinkler mains, branch piping and drops (locate as tight to structure as possible).
11. DDC control wiring and other low voltage systems.
12. Fire alarm systems.
13. Steam piping

C. Chases, Inserts and Openings:
1. Provide measurements, drawings and layouts so that openings, inserts and chases in new construction can be built in as construction progresses.
2. Check sizes and locations of openings provided. Including the access panels for equipment in hard lid ceilings and wall cavities.
3. Any cutting and patching made necessary by failure to provide measurements, drawings and layouts at the proper time shall be done at no additional cost in contract sum.

D. Support Dimensions: Provide dimensions and drawings so that concrete basis and other equipment supports to be provided under other sections of the specifications can be built at the proper time.

E. Coordinate the installation of required supporting devices and sleeves to be set in poured in place concrete and other structural components, as they are constructed.

F. Coordinate the cutting and patching of building components to accommodate the installation of mechanical equipment and materials. Refer to Division 1 and section 23 04 13.

G. Modifications required as result of failure to resolve interferences, provide correct coordinations drawings or call attentions to changes required in other work as result of modifications shall be paid for by responsible Contractor/Subcontractor.

H. Coordination with Electrical Work: Refer to Division 1 and 26.

1.6 DESIGN WORK REQUIRED BY CONTRACTOR:

A. The construction of this project requires the Contractor to include the detailing and design of several systems and/or subsystems. All such design work associated with the development of the coordination drawings shall be the complete responsibility of the Contractor.

B. The Contractor shall take the full responsibility to develop and complete routing strategies which will allow fully coordinated system to be installed in a fully functional manner. The Engineers contract drawings shall be for system design intent and general configurations.

C. Systems or subsystems which require design responsibility by the contractor include but are not limited to:
1. Final coordinated distribution of duct, hydronic, plumbing and other systems within the ceiling cavity.
2. Any system not fully detailed
3. Fire protection systems
4. Equipment supports, hangers, anchors and seismic systems not fully detailed nor specified in these documents, or catalogued by the manufacturer.
5. Temperature controls systems
6. Refrigeration systems

D. Design Limitations:

1. The Contractor shall not modify the Engineers design intent in any way.
2. The Contractor shall not change any duct size, pipe size or equipment size without prior written approval from the Engineer.
3. The Contractor shall conform to the SMACNA Duct Construction Standards when modifying the ductwork layout to avoid collisions.
4. Back to back 90° fittings on duct system shall not be installed under any circumstance.
5. Bull nosed tees on piping systems shall not be installed under any circumstance.

1.7 PROJECT CONDITIONS:

A. The Contractor shall be required to attend a mandatory pre-bid walk-thru and shall make themselves familiar with the existing conditions. No additional costs to the Owner shall be accepted for additional work for existing conditions.

B. Field verify all conditions prior to submitting bids.

C. Report any damaged equipment or systems to the Owner prior to any work.

D. Protect all mechanical and electrical work against theft, injury or damage from all causes until it has been tested and accepted.

E. Be responsible for all damage to the property of the Owner or to the work of other contractors during the construction and guarantee period. Repair or replace any part of the work which may show defect during one year from the final acceptance of all work, provided such defect is, in the opinion of the Architect, due to imperfect material or workmanship and not due to the Owner's carelessness or improper use.

F. The Contractor shall coordinate and co-operate with Owner at all times for all new to existing connections, system shutdowns and start-ups, flushing and filling both new and existing systems.

G. Provide temporary ductwork and piping services, where required, to maintain existing areas operable.

H. Coordinate all services shut-down with the Owner; provide temporary services. Coordinate any required disruptions with Owner, one week in advance.

I. Minimize disruptions to operation of mechanical systems in occupied areas.

1.8 SAFETY:

A. Refer to Division 1.

1.9 EQUAL EMPLOYMENT OPPORTUNITY REQUIREMENTS:

A. Refer to Division 1 and conform with the Owners requirements.
1.10 REQUIREMENTS OF REGULATORY AGENCIES:

A. Refer to Division 1.

B. Execute and inspect all work in accordance with all Underwriters, local and state codes, 2009 UCB Standards, rules and regulations applicable to the trade affected as a minimum, but if the plans and/or specifications call for requirements that exceed these rules and regulations, the greater requirement shall be followed. Follow recommendations of NFPA, SMACNA, EPA, OSHA and ASHRAE.

C. Comply with standards in effect at the date of these Contract Documents, except where a standard or specific date or edition is indicated.

D. The handling, removal and disposal of regulated refrigerants shall be in accordance with U.S. EPA, state and local regulations.

E. The handling, removal and disposal of lead based paint and other lead containing materials shall comply with EPA, OSHA, and any other Federal, State, or local regulations.

F. After entering into contract, Contractor will be held to complete all work necessary to meet these requirements without additional expense to the Owner.

1.11 REQUIREMENTS OF LOCAL UTILITY COMPANIES:

A. Comply with rules and regulations of local utility companies. Include in bid the cost of all valves, valve boxes, meter boxes, meters and such accessory equipment which will be required but not provided by Local Utility Company for the project.

1.12 PERMITS AND FEES:

A. Refer to Division 1.

B. The Contractor shall pay all tap, development, meter, etc., fees required for connection to municipal and public utility facilities, unless directed otherwise by the General Contractor/Owner – IN WRITING.

C. Contractor shall arrange for and pay for all inspections, licenses and certificates required in connection with the work.

1.13 TEMPORARY FACILITIES:

A. Light, Heat, Power, Etc.: Responsibility for providing temporary electricity, heat and other facilities shall be as specified in Division 1.

B. Use of Permanent Building Equipment for Temporary Heating or Cooling: Permanent building equipment shall not be used without written permission from the Owner. If this equipment is used for temporary heating or cooling, it shall be adequately maintained per manufacturer’s instructions and protected with filters, strainers, controls, reliefs, etc. Steam and hydronic systems shall be flushed and chemically treated. (ductwork and air moving equipment shall be cleaned to an “AS New” condition). All filters required for the construction period shall be equivalent to the filters required for the final installation. All filters shall be replaced at the time of substantial completion. The guarantee period of all equipment used shall not start until the equipment is turned over to the Owner for his use. A written record of maintenance, operation and servicing shall be turned over to the owner prior to final acceptance.
1.14 PRODUCT OPTIONS AND SUBSTITUTIONS:

A. Refer to the Instructions to Bidders and Division 1.

1.15 MECHANICAL SUBMITTALS:

A. General

1. Refer to the Conditions of the Contract (General and Supplementary), Division 1.

2. The submittals shall be submitted as one package identified by the specification section. Submittals that are not complete with the required information will be sent back to be corrected.

3. The Contractor shall identify any "long lead time" items which may impact the overall project schedule. If these submittal requirements affect the schedule, the Contractor shall identify the impacts and confer with the Engineer within two weeks of entering into the contract.

4. The submittal package shall be provided in electronic format. The cover shall be identified with the job name, Owner's project number, date, Prime Contractor's name, etc.

5. An index shall be provided which includes:
   a. Product
   b. Plan Code (if applicable)
   c. Specification Section
   d. Manufacturer and Model Number

6. All mechanical divisions shall be submitted at one time. Long lead items may be submitted prior to full submittal if necessary.

7. Fire protection and coordination drawings do not apply to the above. These drawings may be submitted in a separate submittal.

B. The manufacturer's material or equipment listed in the schedule or identified by name on the drawings are the types to be provided for the establishment of size, capacity, grade and quality. If alternates are used in lieu of the scheduled names, the cost of any changes in construction required by their use shall be borne by Contractor.

C. All equipment shall conform to the State and/or local Energy Conservation Standards.

D. Submittal of shop drawings, product data and samples will be accepted only when submitted by and stamped by the General Contractor. Data submitted from Subcontractors and material suppliers directly to the Engineer will not be processed unless prior written approval is obtained by the General Contractor.

E. Before starting work, prepare and submit to the Architect/Engineer all shop drawings and descriptive equipment data required for the project. Unless each item is identified with specification section and sufficient data to identify its compliance with the specifications and drawings, the item will be returned "Revise and Resubmit". Where an entire submittal package is returned for action by the Contractor, the Engineer will summarize comments in letter format and return the entire set. Continue to submit of any individual shop drawings, product data or samples which were returned without a "make corrections noted" or "no exceptions taken" action, until they are so marked. When a "Make Corrections Noted" is
received, make the required corrections for inclusion in the operation and maintenance manual. Submittals marked "Make Corrections Noted" shall not be resubmitted during the submittal process.

F. The Design Professional’s review and appropriate action on all submittals and shop drawings is only for the limited purpose of checking for conformance with the design concept and the information expressed in the contract documents. This review shall not include:

1. Accuracy or completeness of details, such as quantities, dimensions, weights or gauges, fabrication processes
2. Construction means or methods
3. Coordination of the work with other trades
4. Construction safety precautions

G. The Design Professional’s review shall be conducted with reasonable promptness while allowing sufficient time in the Design Professional’s judgment to permit adequate review. Review of a specific item shall not indicate that the Design Professional has reviewed the entire assembly of which the item is a component.

H. The Design Professional shall not be responsible for any deviations from the contract documents not brought specifically to the attention of the Design Professional in writing by the Contractor. This shall clearly identify the design and the specific element which vary from the Design. The Contractor shall be responsible for all remedy for lack of strict conformance associated with this criteria.

I. The Design Professional shall not be required to review partial submissions or those for which submissions of correlated items have not been received.

1.16 SPECIFIC CATEGORY SUBMITTAL REQUIREMENTS:

A. Product Data:

1. Where pre-printed data covers more than one distinct product, size, type, material, trim, accessory group or other variation, mark submitted copy with black pen to indicate which of the variations is to be provided.

2. Delete or mark-out portions of pre-printed data which are not applicable.

3. Where operating ranges are shown, mark data to show portion of range required for project application.

4. For each product, include the following:

   a. Sizes.
   b. Weights.
   c. Speeds.
   d. Capacities.
   e. Piping and electrical connection sizes and locations.
   f. Statements of compliance with the required standards and regulations.
   g. Performance data.
   h. Manufacturer's specifications.

B. Shop Drawings:
1. Shop Drawings are defined as mechanical system layout drawings prepared specifically for this project, or fabrication and assembly type drawings of system components to show more detail than typical pre-printed materials.

2. Prepare Mechanical Shop Drawings, except diagrams, to accurate scale, min 1/8”-1'-0", unless otherwise noted.
   a. Show clearance dimensions at critical locations.
   b. Show dimensions of spaces required for operation and maintenance.
   c. Show interfaces with other work, including structural support.

C. Test Reports:
   1. Submit test reports which have been signed and dated by the accredited firm or testing agency performing the test.
   2. Prepare test reports in the manner specified in the standard or regulation governing the test procedure (if any) as indicated.
   3. Submit test reports as required for O & M manuals.

D. Product Listing:
   1. Prepare listing of major mechanical equipment and materials for the project, within (2) two weeks of signing the Contract Documents and transmit to the Architect. A sample schedule is included at the end of this section to complete this requirement.
      a. Provide all information requested.
      b. Submit this listing as a part of the submittal requirement specified in Division 1, "PRODUCTS AND SUBSTITUTION."
   2. Unless otherwise specified, all materials and equipment shall be of domestic (USA) manufacture and shall be of the best quality used for the purpose in commercial practice.
   3. When two or more items of same material or equipment are required (plumbing fixtures, pumps, valves, air conditioning units, etc.) they shall be of the same manufacturer. Product manufacturer uniformity does not apply to raw materials, bulk materials, pipe, tube, fittings (except flanged and grooved types), sheet metal, wire, steel bar stock, welding rods, solder, fasteners, motors for dissimilar equipment units and similar items used in work, except as otherwise indicated.
      a. Provide products which are compatible within systems and other connected items.

E. Schedule of Values
   1. Provide preliminary schedule of values with product data submittal, within three (3) weeks from award of contract to successful bidder. Provide according to the following descriptions:
      a. HVAC
         1) Equipment – Provide line item pricing for AHU’s, chillers, boilers, cooling towers, Phoenix valves, etc.
         2) Sheet Metal
         3) Piping
         4) Insulation
         5) Test and Balancing
         6) Specialty Systems
7) Temperature Controls

2. Provide a final Schedule of Values at close-out of project including updated values based on actual installation.

F. Coordination Drawings: See section 1.4 of this specification section.

G. Required Submittals: Provide submittals for each item of equipment specified or scheduled in the contract documents. See table at the end of this section.

H. If more than two submittals (either for product data, shop drawings, record drawings, or test and balance reports) are made by the Contractor, the Owner reserves the right to charge the Contractor for subsequent reviews by their consultants. Such extra fees shall be deducted from payments by the Owner to the Contractor.

1.17 DELIVERY, STORAGE, AND HANDLING:

A. Refer to Division 1.

B. Deliver products to project properly identified with names, model numbers, types, grades, compliance labels and similar information needed for distinct identifications; adequately packaged and protected to prevent damage or contamination during shipment, storage, and handling.

C. Check delivered equipment against contract documents and submittals.

D. Store equipment and materials at the site, unless off-site storage is authorized in writing. Protect stored equipment and materials from damage, dirt, dust, freezing, heat and moisture.

E. Coordinate deliveries of mechanical materials and equipment to minimize construction site congestion. Limit each shipment of materials and equipment to the items and quantities needed for the smooth and efficient flow of installations.

F. Provide factory-applied plastic end-caps on each length of pipe and tube, except for concrete, corrugated metal, hub-and-spigot, clay pipe. Maintain end-caps through shipping, storage and handling to prevent pipe-end damage and prevent entrance of dirt, debris and moisture.

G. Protect stored ductwork, pipes and tubes. Elevate above grade and enclose with durable, waterproof wrapping. When stored inside, do not exceed structural capacity of the floor.

H. Protect flanges, fittings and specialties from moisture and dirt by inside storage and enclosure, or be packaging with durable, waterproof wrapping.

I. Protect sheet metal ductwork and fittings. Elevate and store above grade and cover ends with waterproof wrapping.

1.18 CUTTING AND PATCHING:

A. This Article specifies the cutting and patching of mechanical equipment, components and materials to include removal and legal disposal of selected materials, components and equipment.

B. Refer to Division 1.

C. Do not endanger or damage installed work through procedures and processes of cutting and patching.
D. Arrange for repairs required to restore other work, because of damage caused as a result of mechanical installations.

E. No additional compensation will be authorized for cutting and patching work that is necessitated by ill-timed, defective or non-conforming installations.

F. Perform cutting, fitting and patching of mechanical equipment and materials required to:
   1. Uncover work to provide for installation of ill-timed work;
   2. Remove and replace defective work;
   3. Remove and replace work not conforming to requirements of the Contract Documents;
   4. Remove samples of installed work as specified for testing;
   5. Install equipment and materials in existing structures;
   6. Upon written instructions from the Architect/Engineer, uncover and restore work to provide for Architect/Engineer observation of concealed work.

G. Construction and pre-occupancy indoor air quality (AQ) management:
   1. During construction, meet or exceed the recommended design approaches of the SMACNA 1 AQ guideline for occupied buildings under construction, 1995, Chapter 3.

1.19 ROUGH-IN:
   A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.
   B. Refer to equipment shop drawings and manufacturer's requirements for actual provided equipment for rough-in requirements.
   C. Work through all coordination before rough-in begins.

1.20 ACCESSIBILITY:
   A. Install equipment and materials to provide required access for servicing and maintenance. Coordinate the final location of concealed equipment and devices requiring access with final location of required access panels and doors. Allow 36” clearance for removal of all parts that require replacement or servicing.
   B. Extend all grease fittings to an accessible location.
   C. Furnish hinged steel access doors with concealed latch, whether shown on drawings or not, in all walls and ceilings for access to all concealed valves, shock absorbers, air vents, motors, dampers, equipment controls, fans, balancing cocks, and other operating devices requiring adjustment or servicing. Refer to Division 1 for access door specification and Division 23 for duct access door requirements.
   D. The minimum size of any access door shall not be less than the size of the equipment to be removed or 24 inches x 24 inches if used for service only.
   E. Furnish doors to trades performing work in which they are to be built, in ample time for building-in as the work progresses. Whenever possible, group valves, cocks, etc., to permit use of minimum number of access doors within a given room or space.
F. Factory manufactured doors shall be of a type compatible with the finish in which they are to be installed. In lieu of these doors, approved shop fabricated access doors with DuroDyne hinges may be used.

G. Access doors in fire-rated walls and ceilings shall have equivalent U.L. label and fire rating.

1.21 BELTS, SHEAVES, IMPELLERS:

A. The Mechanical Contractor shall coordinate with the Test and Balance Contractor and supply correctly-sized drive belts, sheaves, and trimmed impellers.

1.22 EXCAVATING AND BACKFILLING:

A. General:

1. Provide all necessary excavation and backfill for installation of mechanical work in accordance with Division 2.

B. Contact Owners of all underground utilities to have them located and marked, at least 2 business days before excavation is to begin. Also, prior to starting excavation brief employees on marking and color codes and train employees on excavation and safety procedures for natural gas lines. When excavation approaches gas lines, expose lines by carefully probing and hand digging.

C. Provide all necessary pumping, cribbing and shoring.

D. Walls of all trenches shall be a minimum of 6 inches clearance from the side of the nearest mechanical work. Install pipes with a minimum of 6 inches clearance between them when located in same trench.

E. Pipe Trenching:

1. Dig trenches to depth, width, configuration, and grade appropriate to the piping being installed. Dig trenches to 6 inches below the level of the bottom of the pipe to be installed. Install 6 inches bed of pea gravel or squeegee, mechanically tamp to provide a firm bed for piping, true to line and grade without irregularity. Provide depressions only at hubs, couplings, flanges, or other normal pipe protrusions.

F. Backfilling shall not be started until all work has been inspected, tested and accepted. All backfill material shall be reviewed by the soils engineer. In no case shall lumber, metal or other debris be buried in with backfill.

1. Provide warning tape for marking and locating underground utilities. Tape shall be specifically manufactured for this purpose and shall be polyethylene film, 6 inches wide, 0.004 inches thick and have a minimum strength of 1750 psi. Tape shall carry continuous inscription naming the specific utility.

a. Tape shall have magnetic strip and be used for exterior underground system only.

G. Trench Backfill:

1. Backfill to 12 inches above top of piping with pea gravel or squeegee, the same as used for piping bed, compact properly.
2. Continue backfill to finish grade, using friable material free of rock and other debris. Install in 6 inch layers, each properly moistened and mechanically compacted prior to installation of ensuing layer. Compaction by hydraulic jetting is not permissible.

H. After backfilling and compacting, any settling shall be refilled, tamped, and refinshed at this contractor's expense.

I. This contractor shall repair and pay for any damage to finished surfaces.

J. Complete the backfilling near manholes using pea gravel or squeegee, installing it in 6 inch lifts and mechanically tamping to achieve 95 percent compaction.

K. Use suitable excavated material to complete the backfill, installed in 6 inch lifts and mechanically compacted to seal against water infiltration. Compact to 95 percent for the upper 30 inches below paving and slabs and 90 percent elsewhere.

1.23 NAMEPLATE DATA:

A. Provide permanent operational data nameplate, on each item of mechanical equipment, indicating manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliances, and similar essential data. Locate nameplates in an accessible location. Coordinate with Owner for specific requirements.

B. Campus Famis labels will be provided by UCB for the contractor to install.

1.24 LUBRICATION OF EQUIPMENT:

A. Refer to Division 1. The following paragraphs supplement the requirements of Division 1.

B. Contractor shall properly lubricate all mechanical pieces of equipment which he provided before turning the building over to the Owner. He shall attach a linen tag or heavy duty shipping tag on the piece of equipment showing the date of lubrication and the type and brand of lubricant used.

C. Furnish the Engineer with a typewritten list included in the O and M manuals of each item lubricated and type of lubricant used, no later than two (2) weeks before completion of the project, or at time of acceptance by the Owner of a portion of the building and the mechanical systems involved.

1.25 CLEANING:

A. Refer to Division 1.

B. Refer to Division 23, "TESTING, ADJUSTING AND BALANCING" for requirements for cleaning filters, strainers, and mechanical systems prior to final acceptance.

1.26 RECORD DOCUMENTS:

A. Refer to Division 1. The following paragraphs supplement the requirements of Division 1.

B. Keep a complete set of record document prints in custody during entire period of construction at the construction site. Documents shall be updated on a weekly basis.

C. Mark Drawing Prints to indicate revisions to piping and ductwork, size and location both exterior and interior; including locations of coils, dampers and other control devices, filters, boxes, and similar units
requiring periodic maintenance or repair; actual equipment locations, dimensioned from column lines; actual inverts and locations of underground piping; concealed equipment, dimensioned to column lines; mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located (i.e., traps, strainers, expansion compensators, tanks, etc.); Change Orders; concealed control system devices. Changes to be noted on the drawings shall include final location of any piping or ductwork relocated more than 1 foot-0 inches from where shown on the drawings.

D. At the completion of the project, obtain from the Architect a complete set of the Mechanical Construction Documents in the electronic format used by the design team. This set will include all revisions officially issued through the Architect. The Contractor shall transfer all revisions noted on the record document prints to the electronic drawings. The Contractor shall transmit the final record documents in the electronic format used on the project to the Architect. This contract will not be considered completed until these record drawings have been received and reviewed by the Architect/Engineer.

1.27 OPERATION AND MAINTENANCE DATA:

A. Refer to Division 1.

B. The testing and balancing report shall be submitted and received by the Engineer at least fifteen calendar days prior to the contractor's request for final observation time frame requirements. Include in the O & M Manual after review with "No Exceptions Taken" has been accomplished.

C. In addition to the information required by Division 1 for Maintenance Data, include the following information:

1. Description of mechanical equipment, function, installation instructions, drawing specification, complete wiring and temperature controls diagrams, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of all replaceable parts.

2. Manufacturer's printed operating procedures to include start-up, break-in, routine and normal operating instructions; regulation, control, stopping, shut-down, and emergency instructions; and summer and winter operating instructions. Provide any test reports and start-up documents.

3. Maintenance procedures for routine preventative maintenance and troubleshooting: disassembly, repair, and reassembly; aligning and adjusting instructions.

4. Servicing instructions, lubrication charts and schedules, including Contractor lubrication reports.

5. Manufacturer's service manuals for all mechanical equipment provide under this contract.

6. Include the valve tag list.

7. Alphabetical list of all system components including the name, address and 24 hour phone number of the company responsible for servicing each item during the 1st year's operation.

8. Starting, stopping, lubrication, equipment identification numbers and adjustment clearly indicated for each piece of equipment.

9. Complete parts list. Provide to Owner, recommended spare parts list.

10. Mechanical warranties.
11. Final schedule of values with all mechanical change order costs included and identified.
13. Appropriate start-up information by factory representative.
14. On-site dynamic balancing report by independent balancing firms of all Labs.

D. This contract will not be considered completed nor will final payment be made until all specified material, including testing and balancing report and final schedule of values with all mechanical change order costs included and identified, is received in this operating and maintenance report and the manual is reviewed by the Architect.

1.28 PROJECT CLOSEOUT:

A. In addition to the requirements specified in Division 1, complete the requirements listed below.

B. The Contractor shall be responsible for the following Mechanical Checklist either by performing and/or coordinating such items prior to applying for certification of substantial completion. Refer to individual specification sections for additional requirements.

C. Contractor shall be responsible for scheduling instructional meetings for maintenance personnel on the proper operation and maintenance of all mechanical systems, using the “Operation and Maintenance Manual” as a guide.

1.29 WARRANTIES:

A. Refer to the Division 1 for procedures and submittal requirements for warranties. Refer to individual equipment specifications for warranty requirements. In any case the entire mechanical system shall be warranted no less than one year from the time of acceptance by the Owner.

B. Compile and assemble the warranties specified in Division 21, 22 & 23, into the operating and maintenance manuals.

C. Provide complete warranty information for each item to include product or equipment to include date or beginning of warranty or bond; duration of warranty or bond; and names, addresses, and telephone numbers and procedures for filing a claim and obtaining warranty services.

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1. For Soft Starters and Variable Frequency Drives
2. Requires Review & Approval from T & B Contractor
3. Warranty Report/Warranty
4. Kitchen Exhaust Hood
5. See Specific Specification Section for Test & Certification Requirements

END OF SECTION 23 05 00
SECTION 23 05 13
MECHANICAL/ELECTRICAL REQUIREMENTS FOR MECHANICAL EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. This section specifies the basic requirements for electrical components which are either separate components or are an integral part of all mechanical equipment. These components include, but are not limited to factory installed motors, starters, variable frequency drives and disconnect switches furnished as an integral part of packaged mechanical equipment.

B. Wiring of field-mounted switches and similar mechanical-electrical devices provided for mechanical systems, to equipment control panels.

C. Specific electrical requirements (i.e. horsepower and electrical characteristics) for mechanical equipment are scheduled on the Electrical Drawings. In case of conflict, Electrical Drawings shall take precedence. Do not purchase motors or electrical equipment until power characteristics available at building site location have been confirmed by Contractor.

D. Refer to Table in the Electrical Division for Mechanical/Electrical coordination.

1.2 QUALITY ASSURANCE:

A. Manufacturers: Firms regularly engaged in manufacture of motors, motor starters and drives of types, ratings and characteristics required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Single Manufacturer: Provide all motors and starters for the project by a single manufacturer except when part of factory packaged equipment. All variable frequency drives and soft start starters for the project shall be by a single manufacturer, including packaged equipment except chillers.

C. Installer's Qualifications: Firm with at least 3 years of successful installation experience on projects utilizing motors, motor starters, capacitors and drives similar to that required for this project.

D. NEC Compliance: Comply with NEC as applicable to wiring methods, construction and installation of motors, motor starters, capacitors and drives.

E. NFPA Compliance: Comply with applicable requirements of NFPA 70E, "Standard for Electrical Safety Requirements for Employee Workplaces".

F. UL Compliance: Comply with applicable requirements of UL 486A, "Wire Connectors and Soldering Lugs for Use with Copper Conductors", and UL 508, "Electrical Industrial Control Equipment" pertaining to installation of motor starters.

G. UL Compliance: Provide equipment and components which are UL-listed and labeled.

H. ETL Compliance: Provide equipment and components which are ETL-listed and labeled.


K. Standards:

1. NEMA Standards MG 1: Motors and Generators.
2. NEMA Standard ICS 2: Industrial Control Devices, Controllers, and Assemblies.
5. Comply with National Electrical Code (NFPA 70).

L. Coordination with Electrical Work: Wherever possible, match elements of electrical provisions of mechanical work with similar elements of electrical work specified in Division 16 sections. Comply with applicable requirements of Division 16 sections for electrical work of this section which are not otherwise specified.

1.3 SUBMITTALS:

A. Product Data: Submit in accordance with Section 15010.

B. Shop Drawings: Submit dimensional drawings of VFD’s showing accurately scaled equipment layouts. Drawings shall include, as a minimum: physical dimensions of each unit; general arrangements with incoming and outgoing conduit locations, schematic; connection diagram sufficient to install system, and enclosure details.

C. Wiring Diagrams: Submit schematic power and control wiring diagrams, prepared for this project, of complete VFD assemblies. General wiring diagrams with various non-applicable options shown are not acceptable. Clearly differentiate between factory and field wiring.

D. Listing, Motors of Mechanical Work: Concurrently, with submittal of mechanical products listing, submit separate listing showing rating, power characteristics, efficiencies, power factors, application and general location of every motor to be provided with mechanical work. Submit updated information promptly when and if initial data is revised.

1. Include in listing of motors, notations of whether motor starter is furnished or installed integrally with motor or equipment containing motor.

E. Electrical coordination listing. Provide the following information for each field wired electrical power connection. Information shall use nameplate data and nomenclature of actual installed nameplates. Information should list as a minimum:

1. Field connection details such as maximum/minimum wire size lugs can accommodate. Include number of lugs per phase.
2. Number and location of field connections.
3. Field interconnection wiring.
4. Operating voltage and phase.
5. Maximum fuse size or maximum overcurrent protection size (as applies).
7. Full load amperes.
8. Locked rotor current and duration for high inertia equipment.
9. Manufacturers recommended overload setting (if applicable).

The contractor shall fully coordinate these items with all subcontractors prior to submittal.
1.4 PRODUCT STORAGE:

A. All variable frequency drives shall be protected from dirt, debris, and moisture at all times. Variable frequency drives shall be wrapped air and water tight with dust-tight and moisture proof material until factory start-up of variable frequency drives is initiated.

   Exception: Drives may be opened only during wiring terminations by temperature control contractor and/or electrical contractors.

B. All motors not designed for exposure to water or moisture shall be protected at all times.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Subject to compliance with requirements, provide products by one of the following manufacturers for each type of product:

1. Motors

   a. AO Smith
   b. Baldor
   c. Reliance
   d. Westinghouse
   e. Toshiba
   f. Gould
   g. General Electric
   h. Louis Allis
   i. Lincoln
   j. ABB

2. Starters:

   a. Cutler Hammer
   b. Allen-Bradley
   c. Sprecher & Schuh
   d. Square D
   e. General Electric
   f. Westinghouse
   g. Siemens

3. Variable Frequency Drives

   a. Robicon
   b. ABB
   c. Reliance
   d. Motor Drive International, Inc. (Mitsubishi)
   e. Toshiba
   f. Cutler Hammer
2.2 **MOTORS:**

A. The following are basic requirements for simple or common motors. For special motors, more detailed and specific requirements are specified in the individual equipment specifications.

1. Torque characteristics shall be sufficient to satisfactorily accelerate the driven loads with a time limit acceptable to the motor manufacturer. Motors shall be capable of starting the driven equipment while operating at 90 percent rated terminal voltage.

2. Motor sizes shall be large enough so that the driven load will not require the motor to operate in the service factor range.

3. 2-speed motors shall have (1) single winding on poly-phase motors.


5. Temperature Rating: Rated for 40 degrees C environment with maximum 80 degrees C temperature rise for continuous duty at full load (Class B Insulation). Provide Class F insulation for variable frequency drive motors.

6. Starting capability: Frequency of starts as indicated by automatic control system, and not less than 5 evenly time spaced starts per hour for manually controlled motors.

7. Service Factor: 1.15 for poly-phase motors, 1.35 for single phase motors, and 1.0 for inverter duty motors.

8. Altitude Deration: Motors must be selected to operate within nameplate horsepower at 5400 ft. elevation.

9. All motors rated greater than 1000W shall have a power factor of not less than 85% under rated load condition.

10. Motor construction: NEMA Standard MG 1, general purpose, continuous duty, Design "B", except "C" where required for high starting torque. Design "E" shall not be used.

   a. Frames: NEMA Standard No. 48 or 54; Use driven equipment manufacturer's standards to suit specific application.

   b. Bearings:

      1) Ball bearings with inner and outer shaft seals.

      2) Re-greasable, except permanently sealed where motor is normally inaccessible for regular maintenance.

      3) Bearings shall be rated for minimum L-10 life of 40,000 hours.

      4) Designed to resist thrust loading where belt drives or other drives produce lateral or axial thrust in motor.

      5) For fractional horsepower, light duty motors, sleeve type bearings are permitted.
c. Enclosure Type:
   1) Open drip-proof motors for indoor use where satisfactorily housed or remotely located during operation.
   2) Guarded drip-proof motors where exposed to contact by employees or building occupants.
   3) Weather protected Type I for housed outdoor use, TEPC II where not housed.
   4) All cooling tower fan motors shall be TEFC type.

d. Overload protection: Built-in thermal overload protection for all single phase motors and, where indicated, internal sensing device suitable for signaling and stopping motor at starter.

e. Noise rating: "Quiet". Motors shall not exceed 80DB rating when running their full speed and power range.

f. Motors 1hp and higher are to be premium efficient, complying with Xcel Energy requirements.

g. All belt-drive motors over 5hp shall have dual push-pull adjustment screws for the motor mounts. For retrofits, the motor mounts must be replaced if not of this type.

h. Nameplate: indicate the full identification of manufacturer, ratings, characteristics, construction, special features and similar information.

11. Phases and Current Characteristics: Unless indicated otherwise, provide squirrel-cage induction polyphase motors for 3/4 hp and larger, and provide capacitor-start single-phase motors for 1/2 hp and smaller, except 1/6 hp and smaller may, at equipment manufacturer's option, be split-phase type. Tri-voltage motors are not acceptable. Coordinate current characteristics with power specified in Division 16 sections. Do not purchase motors until power characteristics available at building site have been confirmed by contractor.

12. The Contractor shall be responsible for all additional electrical and other costs involved to accommodate any motors which differ from the scheduled horsepower sizes or correct any motor which does not meet the listed efficiency as called for in mechanical or electrical plans and specifications.

13. Motors shall be of the same manufacturer, except those that are an integral part of a factory assembled packaged unit. These motors shall likewise meet the conditions of the specification in this section except motors which are part of a motor/compressor assembly are exempted from this requirement.

14. All motors 75 HP and larger shall be factory test certified for power factor, efficiency, and shall have a three year warranty. Factory certification of motor tests shall be provided to the Owner.

15. All equipment specified to operate with variable frequency drives shall be provided with inverter-duty motors specifically designed for variable speed operation with high efficiency at part load conditions and constructed with Class F inverter grade insulation. Inverter duty motors shall meet requirements of NEMA MG-1 part 31.4 O.4.2.

16. All motors which will be operated by a variable frequency drive shall be warranted against any damage or defects as a result of being used with a variable frequency drive.
2.3 STARTERS, ELECTRICAL DEVICES AND WIRING:

A. Motor Starter Characteristics:

1. Coordinate with the Electrical Contractor for motor control center starters provided by Division 16.
2. Enclosures: NEMA 1, general purpose enclosures with padlock ears, except in wet locations shall be NEMA 3R with conduit hubs, or units in hazardous locations which shall have NEC proper class and division.
3. Type and size of starter shall be as recommended by motor manufacturer and the driven equipment manufacturer for applicable protection and start-up condition.
4. Provide two-speed starters with a High-Low selector switch wired to allow manual speed selection with the H-O-A in HAND or remote speed selection in AUTO. Provide an automatic accelerating relay/timer to assure that the motor will always start at low speed and operate at an adjustable time before switching to high speed. Also, provide an integral automatic decelerating timing relay to prevent damage to the motor and load when switching from high to low speed. High and low speed contactors shall be mechanically and electrically interlocked. Complete instructions shall be provided for adjusting the timer in the field to match the deceleration characteristics of the driven equipment.
5. Contacts shall open each ungrounded connection to the motor. Contacts shall be NEMA style, sized and rated, 75 degrees C.

B. Manual switches shall have:

1. Maintained contacted push buttons with pilot lights for single-speed or multi-speed operation.
2. Overload protection: melting alloy type thermal overload relays.

C. Magnetic Starters:

1. Unless otherwise indicated, provide NEMA style, sized and rated magnetic starters including contacts and coils for motors 1/2 hp and larger and for smaller motors where interlock or automatic operation is indicated or required:
   a. Maintained contact H-O-A push buttons and pilot lights, properly arranged for single speed or multi-speed operation as indicated.
   b. Solid state adjustable motor overload. Select range so that upper limit is no more than 150 percent of the connected motor full load amps.
   c. Interlocks, pneumatic switches and similar devices as required for coordination with control requirements of Division-15 Controls sections. In addition to the interlock & switches specified above each starter shall be provided with (4) four additional spare sets of auxiliary contacts, (2) two normally open & (2) two normally closed.
   d. Built-in 120 volts control circuit transformer, fused from line side, where service exceeds 240 volts.
   e. Under-voltage release or protection. Re-start of equipment shall be automatic.
   f. All 3-phase motors 2 hp and larger shall be protected against loss of phase (single phasing protection) wired into the starter. Externally operated manual reset.
   g. Where reduced voltage starting is required, the starting method shall be part winding or closed transition auto-transformer/solid state electronic starting. Motors shall be constructed accordingly. Other methods of reduced voltage starting shall not be used unless reviewed by the Engineer prior to bid.
   h. All starters used for life safety systems shall have an additional control relay to by-pass all external safeties and internal safeties except for overload protection. Coordinate with 15975.
D. Motor connections:

1. Flexible conduit, except where plug-in electrical cords are specifically indicated.

2.4 DISCONNECT SWITCHES:

A. See Division 16 for requirements.

2.5 DRIVES:

A. V-Belt Drives:

1. Capacity of V-Belt Drives at rated RPM shall be not less than 150 percent of motor nameplate horsepower rating.
2. V-Belt Drive combinations shall be limited to A, B, C and fractional horsepower belts. 3V, 5V and 8V belts and sheaves shall not be used.
3. Motors and Fan Wheel Pulleys: Adjustable pitch for use with motors through 15 HP; fixed pitch for use with motors larger than 15 HP. Select pulley so that pitch adjustment is at the middle of the adjustment range at fan design conditions.
4. All fixed pitch sheaves, including single groove fan sheaves, shall be of the bushed type. Fixed bore sheaves will not be acceptable for adjustable pitch sheaves.
5. Belts: Oil-resistant, nonsparking, and nonstatic.
6. Unit manufacturer shall provide OSHA approved belt guard with tachometer holes.
7. For equipment serving hazardous or critical systems (i.e., fume hoods, bio-hazards, life safety, etc.), all fans shall be provided with 1.5 times the number of belts normally required to meet above requirements, with a minimum of 2 belts.

2.6 VARIABLE FREQUENCY DRIVES:

A. General:

1. Comply with NEMA (including NEMA ICS 7.1), and IEEE (including IEEE 519-1992) Standards as applicable to wiring methods, construction and installation and operation of VFDs. Comply with applicable requirements of UL 908. “Power Conversion Equipment” and UL 508 C. Provide units which have been UL-listed and labeled by Underwriters Laboratory or ETL Testing. The entire unit shall carry this label, not just components.
2. Provide the following factory tests on VFD assembly as a complete package (not just individual components):
   a. High pot test per UL 508.
   b. Test assembled panel with a motor load.
   c. Test operation of all components and pilot lights.
   d. The VFD shall be tested with system logic and given complete factory tests including simulated operation.
3. The VFD shall be of sufficient capacity and provide a quality of output wave form so as to achieve full rated output of the motors. The VFD shall be capable of operating any standard NEMA design B squirrel cage induction motor (3-phase, 60Hz), with full-load amp rating between 10 percent and 110 percent of the drive full-load current capability w/o requiring modification.
4. The manufacturer shall verify compatibility of each VFD unit with the motor being supplied under Division 15. The vendor shall be responsible for reviewing Division 15 specifications
sections, plans and schedules related to motors prior to bid and shall notify the Engineer at least ten (10) days prior to the bid of any discrepancies or incompatibilities between VFD units and motor characteristics.

5. Each VFD shall be of the pulse width modulation design.

6. A separately housed bypass shall be provide to allow complete by-pass and removal of VS controller only on pumps, and a case by case on air handling units.

B. Enclosure:

1. Mount VFD and all components within a NEMA 1 metal enclosure. By-pass components shall be in a separate compartment or enclosure as noted below.
2. Provide floor stand where building walls are not suitable for mounting drive.
3. Provide filtered, fan powered ventilation for drive cooling. Fan shall be sized for “dirty filter” condition, at project altitude.
4. Drive and by-pass enclosure doors shall have provisions for locking with a padlock or integral lock, keyed to the building standards.
5. Switches and pilot lights shall be labeled with engraved plastic laminate tags riveted or similarly permanently fastened.
6. Motors must have insulation rated 1600 volts or greater.
7. Motors shall be NEMA design B with Class F installation.

C. Input Power:

1. The drive shall be capable of accepting facility power as specified on the drawings. Variations of up to plus or minus 10 percent of line voltage and plus or minus 2HZ of line frequency shall be permitted without the drive shutting down on a fault.
2. Power line interruptions of up to 0.5 seconds shall be permitted without the drive shutting down on a fault.
3. The drive input circuitry shall not generate line notches or large voltage transients on the incoming line.
4. The drive efficiency at rated load and frequency shall be 95 percent or better.
5. The drive shall present a displacement power factor of 0.95 or better to the AC line at any speed or load.
6. Manufacturer shall guarantee that harmonic voltage and current distortion, on the line side (input terminals) of the VFD does not exceed 5 percent total voltage Harmonic distortion, and 15 percent total current Harmonic distortion.
   a. Manufacturer shall correct harmonic voltage and current distortion with an AC line reactor, an isolation transformer, or a tuned filter to stay within the above limit.
   b. Manufacturer shall review electrical drawings to determine optimum characteristics of the reactor/filter system.
   c. The installed drive shall be tested to verify the above distortion limits. The manufacturer shall replace the reactor/filter system if the installed drive does not meet the THD criteria. See Part 3.

D. Output Power:

1. The variable frequency AC drive shall convert 3 phase, 60 HZ input power to an adjustable AC frequency and voltage for controlling the speed of any standard NEMA B Design, AC squirrel cage motors driving variable torque loads. The drive shall be rated for continuous duty at the NEC standard full load current of it’s associated motor.
2. Transistors (IGBT) to produce a sine weighted PWM three phase output for the load.
3. The drive shall have sufficient capacity to provide stepless speed control of the motor throughout the operating range as specified herein.
4. The drive output will be adjustable from 0 to 60 HZ.
5. The drive shall have the capability to adjust the frequency above 4 kHz. The drive shall not operate with a frequency above 12 kHz.
6. The IGBTs shall have a minimum rating of 1200 VDC on 480 V units and 600 VDC on 230 V units.
7. The drive shall be suitable for operating at the altitude of the project location with no degradation or loss of performance.

E. Line Noise Protection:

1. VSC’s shall be equipped with factory installed reactors or separate isolating transformer as called for on the plans to minimize the effects of harmonics and “line notching” on the building distribution system. Manufacturer shall optimize the impedance of reactors or transformer and provide calculations to the owner certifying that the installed system is within IEEE-519 standards. Care should be taken in specifying transformer impedance so the transfer can support across-the-line starting of the driven motor in a standby mode.

F. Control and Operation Features:

1. Adjustable acceleration and deceleration, independent acceleration/deceleration rates: 0.5-120 seconds. Regeneration or dynamic braking will not be required for deceleration.
2. Speed/frequency settings to limit the maximum and minimum motor speed, to avoid up to 3 system critical resonance points and to provide a preset speed for operation in the event of loss of the remote speed signal.
3. Capability to set drive to a pre-determined speed upon a contact closure input from the BAS.
4. Capability of restarting into a rotating motor.
5. The following operator control and monitoring functions shall be accessible without opening the door of the enclosure.
   a. HAND/OFF/AUTO (or Local/Off/Remote) selector switch.
      1) With the “H-O-A” switch in the “HAND” or “LOCAL” position, the motor shall start in either VFD or by-pass mode as determined by VFD/OFF/BYPASS switch, and if in the “VFD” mode, the speed be controlled by the manual mode on the drive door.
      2) With the “H-O-A” switch in “AUTOMATIC.” The drive shall start and its speed shall be controlled by a 4 to 20 mA input speed signal.
      3) With the “H-O-A” switch in the “OFF” position, the run circuit will be open and the VSC will not operate.
      4) This must be a physical switch, not a keypad input function.
   b. Manual (local) speed adjustment.
   c. Frequency (speed) indication.
   d. Output amperage indication.
   e. Pilot lights for:
      1) Power On (green)
      2) VFD Fault (red)
3) External Fault (red)
4) Motor on VFD (green)
5) Motor on By-pass (red)
6) Motor Overload (red)

6. The following control interfaces shall be provided:

a. Remote start/stop (run enable input)
   1) Provide a control relay and a terminal block in the by-pass compartment to allow remote start/stop in either the VFD or by-pass mode.

b. Remote speed input signal
   1) 4-20 mA, 0-5 VDC, 0-10 VDC, or as required by control system. Coordinate with 15971.

c. Safeties interlock input
   1) Provide a control relay and terminal block in the by-pass compartment to allow hardwired safety shutdown in either the VFD or by-pass mode.

d. Fault indication output contacts. Indicate fault for the following:
   1) Drive protection features
   2) Safety interlock
   3) Drive hardware fault
   4) Input power fault
   5) Others as provided by manufacturer

e. Speed indication output (isolated)

f. Amperage indication output.

g. Run forward input.

h. Run backward input.

i. Drive running (status) output.

j. Drive on by-pass output.

k. Drive on manual output.

l. Pre-set speed input.

m. RS 485 communications to DDC system.

n. Complete open protocol communications with DDC system.

7. Provide a key pad and scrolling LCD display for operator interface with programming capabilities, fault diagnostics, fault reset, and security lockout code. Information shall be presented in plain English, not requiring codes.
a. Key pad shall be accessible without opening enclosure panel door.

8. In addition to the interlock and switches specified above, each variable frequency drive shall be provided with (4) four additional spare sets of auxiliary contacts, (2) two normally open and (2) two normally closed.

G. Drive protection and safety features:

1. Ground fault protection.
2. Electronic motor overload protection.
3. Over-voltage/under-voltage protection.
   a. The VFD shall be arranged to provide automatic restart after a trip condition resulting from over-voltage or under-voltage.
   b. For safety, the drive shall shut down and require manual reset and restart if the automatic reset/restart function is not successful within a maximum of five attempts.
4. Inverse characteristic time-overcurrent overload protection for the motor sized in accordance with NEC requirements.
5. Drive shall be capable of withstanding random application of an output short circuit without damage to drive components or fuses.
6. Input phase loss and undervoltage protection.
7. Torque/current limit control which will slow the motor without tripping when the motor is subjected to an overload, or slow the acceleration ramp when accelerating a high inertia load.
8. High/over temperature protection.
9. VFD shall include a “Bus Charged” warning indicator, and shall be provided with automatic circuitry to discharge the bus within 120 seconds after main power is disconnected.

H. For drive manufacturers who use portable test meter for diagnostics, provide not less than one test meter for every five (5) variable frequency drives for each model or type used. Meters shall be supplied to the Owner upon completion of the project.

I. Each drive shall include an RS 232 port with 25 pin "D" connector to allow downloading of parameter settings and fault history logs to a standard IBM compatible portable computer or printer. Software to allow download of setting shall be included.

J. The audible dBA sound level of the complete system (motor & VFD) when operated over the full speed range shall be not more than 10 percent above the sound level of the motor operated in the by-pass mode (60 hZ building power). This test will be performed during initial startup. Corrections needed to achieve this requirement shall be made by the VFD supplier at no cost to the Owner.

K. All variable frequency drives shall be warranted for 36 months after the building has been accepted by the Owner. This warranty shall include all parts, labor, materials, shipping cost, travel, lodging and meals with no cost to the Owner.

L. Provide one complete spare set of all fuses used in each VFD supplied.

2.7 EQUIPMENT FABRICATION:

A. General: Fabricate mechanical equipment for secure mounting of motors and other electrical items included in work. Provide either permanent alignment of motors with equipment, or adjustable mountings as applicable for belt drives, special couplings and similar indirect coupling of equipment.
Provide safe, secure, durable, and removable guards for motor drives, arranged for lubrication and similar running-maintenance without removal of guards.

PART 3 - EXECUTION

3.1 TEST AND TEST DATA:

A. A factory load test shall be performed on each motor of 1000 watt input or greater to assure compliance with the energy-efficiency section of this specification.

B. Typical test data on every motor to be used on this project shall be made available upon request.

3.2 INSTALLATION:

A. Install motors on motor mounting systems in accordance with motor manufacturer's instructions, securely anchored to resist torque, drive thrusts, and other external forces inherent in mechanical work. Secure sheaves and other drive units to motor shafts with keys and Allen set screws, except motors of 1/3 hp and less may be secured with Allen set screws on flat surface of shaft. Unless otherwise indicated, set motor shafts parallel with machine shafts.

B. Deliver starters and wiring devices which have not been factory-installed on equipment unit to electrical installer for installation.

C. Install power and control connections for motors to comply with NEC and applicable provisions of Division 16 sections. Install grounding except where non-grounded isolation of motor is indicated.

D. Provide 4 inch high concrete housekeeping pad for floor mounted variable frequency drive.

E. Where a separate disconnect switch is provided in the motor feeders between a VFD and the motor, provide an end switch at the disconnect to open the remote interlock shutdown circuit power circuit.

3.3 VFD START-UP SERVICES:

A. Provide field start-up service by an authorized factory trained service representative. The factory representative shall be trained in the maintenance and troubleshooting of the equipment as specified herein. Start-up services shall include system check-out, start-up and system run. The VFD and bypass shall be tested and started under actual conditions by factory trained personnel. One day of technicians time shall be included in the base bid for checkout/start-up.

B. Start-up adjustments shall include optimizing frequency, optimizing volts/Hz ratio, identifying and avoiding resonant speeds, setting accel/decel ramps, and setting overload and circuit breaker trip points.

3.4 VFD HARMONIC DISTORTION TESTING:

A. After installation is complete, measure the harmonic voltage and current distortion of each VFD with the drive assembly in by-pass mode, with the VFD running at 50 percent operating speed and with the VFD running at highest operating speed. Take measurements on each phase (L-L) on the line side (input terminals) of the VFD.

B. If measurements exceed the limits as specified in Part 2, install corrective reactors or filters at no additional cost to the owner and retake measurements after corrective equipment is installed.
C. Include all measurements (before and after) in the harmonic distortion report. Provide the Engineer with a copy of the harmonic distortion report.

D. The Harmonic Distortion Test and Report shall be conducted by an approved independent testing agency.

3.5 **VFD NOISE TEST:**

A. Measure the dBA sound level of the motor with the drive in by-pass mode, and with the drive operating at 25 percent, 75 percent, and 100 percent speed output.

B. If the measurements exceed the limits specified in part 2, correct as required at no cost to the Owner, and retake measurements.

C. Report all tests to the Engineer.

3.6 **VFD INDUCED SHAFT VOLTAGE TEST:**

A. After installation is complete, and system is operating under normal conditions, measure and report any voltage potential between the motor shaft and the motor frame, this test may occur anytime between substantial completion and the end of the overall project warranty period. Report findings to the Engineer. Costs for any corrective measures required shall not be included in the bid.

3.7 **INSTALLATION COORDINATION:**

A. Furnish equipment requiring electrical connections to operate properly and to deliver full capacity at electrical service available.

B. Verify windings of multi-speed or reduced voltage starters are compatible with the connected motor prior to installation.

C. All control wiring to be in accordance with manufacturer's recommendations; all wiring shall be color coded to facilitate checking.

D. It is the intent of this specification that one "General" Contractor enters an agreement with the Owner. The use and coordination of subcontractors is at the option of the General Contractor. All mechanical equipment, motors and controls shall be furnished, set in place, and wired. The schedule contained in the Electrical Division is provided as a guide only. The exact furnishing and installation of the equipment is left to the Contractors involved. Contractor should note that the intent of the schedule is to have the Division 15 and 16 Contractors responsible for coordinating all control wiring as outlined, whether or not specifically called for by the mechanical or electrical drawings and specifications. Comply with the applicable requirements of Division 16 for all electrical work which is not otherwise specified. No extras will be allowed for Contractor's failure to provide for these required items. The Contractor shall refer to the Division 16 and Division 15 specifications and plans for all power and control wiring and shall advise the Architect/Engineer of any discrepancies prior to bidding.

END OF SECTION 23 05 13
SECTION 23 05 18
HVAC PIPING SPECIALTIES

PART 1 GENERAL

1.1 DESCRIPTION OF WORK:

A. Extent of piping specialties work required by this section is indicated on drawings and schedules and by requirements of this section.

B. Piping specialties furnished as part of factory-fabricated equipment, are specified as part of equipment assembly in other Division-23 sections.

1.2 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of piping specialties of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Codes and Standards:

1. FCI Compliance: Test and rate "Y" type strainers in accordance with FCI 73-1 "Pressure Rating Standard for "Y" Type Strainers". Test and rate other type strainers in accordance with FCI 78-1 "Pressure Rating Standard for Pipeline Strainers Other than "Y" Type".

2. ASME B 31.9 "Building Services Piping" for materials, products, and installation.

3. Safety valves and pressure vessels shall bear the appropriate ASME label.

4. Fabricate and stamp air separators and compression tanks to comply with ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

5. ASME "Boiler and Pressure Vessel Code", Section IX, "Welding and Brazing Qualification" for qualifications for welding processes and operators.

1.3 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data, including installation instructions, and dimensioned drawings for each type of manufactured piping specialty. Include pressure drop curve or chart for each type and size of pipeline strainer. Submit schedule showing manufacturer's figure number, size, location, and features for each required piping specialty.

B. Shop Drawings: Submit for fabricated specialties, indicating details of fabrication, materials, and method of support.

C. Maintenance Data: Submit maintenance data and spare parts lists for each type of manufactured piping specialty. Include this data, product data, and shop drawings in maintenance manual; in accordance with requirements of Divisions 23.
PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Manufacturer: Subject to compliance with requirements, provide products by one of the following:

1. Combination Pressure and Temperature Relief Valves:
   a. Amtrol, Inc.
   b. Bell & Gossett ITT; Fluid Handling Div.
   c. Spirax Sarco.
   d. Watts Regulator Co.

2. Air Vents:
   b. Bell & Gossett ITT; Fluid Handling Div.
   c. Hoffman Specialty ITT; Fluid Handling Div.
   d. Spirax Sarco.
   e. Amtrol, Inc.

3. Air Separators:
   a. Amtrol, Inc.
   b. Armstrong Pumps, Inc.
   c. Bell & Gossett ITT; Fluid Handling Div.
   d. Taco, Inc.

4. Diaphragm/Bladder-Type Compression Tanks:
   a. Amtrol, Inc.
   b. Armstrong Pumps, Inc.
   c. Bell and Gossett ITT; Fluid Handling Div.
   d. Taco, Inc.
   e. The John Wood Co.
   f. Wessles

5. Hydronic System Safety Relief Valves:
   a. Kunkle Valve Co., Inc.
   b. Lunkenheimer Co.
   c. Watts Regulator Co.
   d. Loneragan
   e. Keckley
   f. Bell & Gossett ITT; Fluid Handling Div.
   g. Conbraco

6. Pipe Escutcheons:
   b. Producers Specialty & Mfg. Corp.
7. Low Pressure Strainers:
   a. Metraflex Co.
   b. R-P&C Valve; Div. White Consolidated Industries, Inc.
   c. Spirax Sarco.
   d. Trane Co.
   e. Victaulic Co. of America.
   f. Watts Regulator Co.

8. High Pressure Y-Type Strainers:
   b. Hoffman Specialty ITT; Fluid Handling Div.
   c. Metraflex Co.
   d. R-P&C Valve; Div. White Consolidated Industries, Inc.
   e. Spirax Sarco.
   f. Trane Co.
   g. Watts Regulator Co.

9. Basket Strainers:
   a. Armstrong
   b. AW Cash
   c. Boylston
   d. Hoffman
   e. ITT
   f. Mueller
   g. Plenty
   h. Keckley

10. Dielectric Waterways
    a. Victaulic Co.
    b. Perfection Corp.
    c. Flow Design Inc.
    d. Perfection Corp.
    e. Rockford-Eclipse Div.

11. Mechanical Sleeve Seal:
    a. Thunderline Corp.
    b. Metra Flex.

2.2 HYDRONIC PIPING SPECIALTIES:

   A. General: Provide factory-fabricated piping specialties recommended by manufacturer for use in service indicated. Provide piping specialties of types and pressure ratings indicated for each service, or if not indicated, provide proper selection as determined by Installer to comply with installation requirements. Provide sizes as indicated, and connections, which properly mate with pipe, tube, and equipment connections. Where more than one type is indicated, selection is Installer's option.

   B. Hydronic System Safety Relief Valves: Diaphragm operated, cast-iron or brass body valve, with low inlet pressure check valve, inlet strainer removable without system shut-down, and noncorrosive valve seat and stem. Select valve size, capacity, and operating pressure to suit system. Valve shall be
factory-set at operating pressure to suit system and have the capability for field adjustment. Safety relief valve shall be designed, manufactured, tested and labeled in accordance with the requirements of Section IV of the ASME Boiler and Pressure Vessel Code. Valve body shall be cast-iron, with all wetted internal working parts made of brass and rubber; 125 psig working pressure and 250 degrees F maximum operating temperature. Select valve to suit actual system pressure and BTU capacity. Set valve to relieve at 10 psi above operating pressure.

C. Pressure Reducing Valves: Diaphragm operated, bronze or brass body valve, with low inlet pressure check valve, stainless steel inlet strainer removable without system shut-down, and stainless steel valve seat and stem. Select valve size, capacity, and operating pressure to suit system. Valve shall be factory-set at operating pressure and have the capability for field adjustment.


E. Automatic Air Vent: 100 psi working pressure, 240 degrees working temperature, stamped brass body and non-metallic float, with threaded outlet connector for "safe waste" discharge pipe.

1. Amtrol 703 or approved equivalent.

F. High Capacity Automatic Air Vent: 150 psig working pressure, 250 degrees working temperature, cast iron body, bronze pilot mechanism. Snap acting operation, preventing opening under negative pressure conditions. Capable of 18 scfm elimination at 30 psig.

1. Amtrol 720 or approved equivalent.

G. Air Separators: Welded black steel; ASME constructed and labeled for minimum 125 psig water working pressure and 350 degrees F operating temperature; perforated stainless steel air collector tube; tangential inlet and outlet connections; screwed connections up to and including 3 inch NPS; flanged connections for 4 inch NPS and above; threaded blowdown connection; sized as indicated for full system flow capacity.

H. Diaphragm/Bladder-Type Compression Tanks: Size and number as indicated; construct of welded carbon steel for 125 psig working pressure, 240 degrees F maximum operating temperature. Separate air charge from system water to maintain design expansion capacity, by means of a flexible heavy duty diaphragm securely sealed into tank. Diaphragm shall be permanently sealed for tank sizes up to 45 gallon acceptance volume. For acceptance volumes greater than 45 gallons, tank shall have replaceable diaphragm/bladder. Diaphragm/bladder shall be suitable for glycol service and system water treatment chemicals. Provide taps for pressure gauge and air charging fitting, and drain fitting. Support vertical tanks with steel legs or base; support horizontal tanks with steel saddles. Tank, with taps and supports, shall be constructed, tested, and labeled in accordance with ASME Pressure Vessel Code, Section VIII, Division 1.

2.3 PIPE ESCUTCHEONS:

A. General: Provide pipe escutcheons as specified herein with inside diameter closely fitting pipe outside diameter, or outside of pipe insulation where pipe is insulated. Select outside diameter of escutcheon to completely cover pipe penetration hole in floors, walls, or ceilings; and pipe sleeve extension, if any. Furnish pipe escutcheons with nickel or chrome finish for occupied areas, prime paint finish for unoccupied areas.

B. Pipe Escutcheons for Moist Areas: For waterproof floors, and areas where water and condensation can be expected to accumulate, provide cast brass or sheet brass escutcheons, solid or split hinged.

C. Pipe Escutcheons for Dry Areas: Provide sheet steel escutcheons, solid or split hinged.
2.4 **LOW PRESSURE PIPELINE STRAINERS:**

A. General: Provide strainers full line size of connecting piping, with ends matching piping system materials. Select strainers for 125 psi working pressure, with Type 304 stainless steel screen. Two inches and smaller steam and liquid strainers shall have 20 mesh screens. Provide 3/64 inch perforations for 2-1/2 inch and 3 inch steam and liquid strainers. Provide 1/8 inch mesh perforations for 4 inches and larger liquid strainers. Provide 1/16 inch mesh perforations for 4 inches and larger steam strainers.

B. Threaded Ends, 2 inch and Smaller: Bronze or Cast-iron body, screwed screen retainer with centered blowdown fitted with pipe plug.

C. Threaded Ends, 2-1/2 inches and Larger: Cast-iron body, bolted screen retainer with off-center blowdown fitted with pipe plug.

D. Flanged Ends, 2-1/2 inches and Larger: Cast-iron body, bolted screen retainer with off-center blowdown fitted with pipe plug.

E. Butt Welded Ends, 2-1/2 inches and Larger: Schedule 40 cast carbon steel body, bolted screen retainer with off-center blowdown fitted with pipe plug.

2.5 **HIGH PRESSURE PIPELINE STRAINERS:**

A. General: Provide strainers full line size of connecting piping, with ends matching piping system materials. Select strainers for 250 psi working pressure, with Type 304 stainless steel screens. Two inches and smaller steam and liquid strainers shall have 20 mesh screens. Provide 3/64 inch perforations for 2-1/2 inch and 3 inch steam and liquid strainers. Provide 1/8 inch mesh perforations for 4 inch and larger liquid strainers. Provide 1/16 inch mesh perforations for 4 inch and larger steam strainers.

B. Threaded Ends, 2 inches and Smaller: Cast-iron body, screwed screen retainer with centered blowdown fitted with pipe plug.

C. Threaded Ends, 2-1/2 inches and Larger: Cast-iron body, bolted screen retainer with off-center blowdown fitted with pipe plug.

D. Flanged Ends, 2-1/2 inches and Larger: Cast-iron body, bolted steel retainer with off-center blowdown fitted with pipe plug.

E. Butt Welded Ends, 2-1/2 inches and Larger: Schedule 80 cast carbon steel body, bolted screen retainer with off-center blowdown fitted with pipe plug.

2.6 **BASKET STRAINERS:**

A. For 125 psig systems or less (thru 12 inch): High-Tensile ASTM A126, Class B cast iron, angle design, bolted cover, flanged ends, stainless steel screen assembly, suitable gasket material, bottom threaded drain outlet. Steam screen size shall be .045 inch perforations for through 6 inch diameter piping; .062 inch for 8 inch and larger. Liquid screen size shall be .045” perforations for through 3 inch diameter piping; .125 inch for 4 inch and larger.

R-P&C 528-V12, Class 125

B. For systems operating greater than 125 psig (thru 12 inch): High-Tensile ASTM A126 Class B cast iron, angle design, bolted cover, flanged ends, stainless steel screen assembly, suitable gasket material,
bottom threaded drain outlet. Steam screen size shall be .045 inch perforations for through 6 inch diameter piping; .062 inch for 8 inch and larger. Liquid screen size shall be .045 inch perforations for through 3 inch diameter piping; .125 inches for 4 inches and larger.

R-P&C 528-B25, Class 250

2.7 DIELECTRIC WATERWAY:

A. General: Zinc electroplated nipple with non metallic lining for use in service indicated, which effectively isolate ferrous from non-ferrous piping (electrical conductance), prevent galvanic action, and stop corrosion. Union style not acceptable. Shall conform to ASA B16.8, plated as applicable a minimum of .0005” and have no flow restrictions when assembled.

2.8 MECHANICAL SLEEVE SEALS:

A. General: Modular mechanical type, consisting of interlocking synthetic rubber links shaped to continuously fill annular space between pipe and sleeve, connected with bolts and pressure plates which cause rubber sealing elements to expand when tightened, providing watertight seal and electrical insulation, as manufactured by Link-Seal or equal.

B. Sleeve Seals: Provide sleeve seals for sleeves located in foundation walls below grade, or in exterior walls, of one of the following:

1. Mechanical Sleeve Seals: Installed between sleeve and pipe.

2.9 FABRICATED PIPING SPECIALTIES:

A. Drip Pans: Provide drip pans fabricated from corrosion-resistant sheet metal with watertight joints, and with edges turned up 2-1/2 inches. Reinforce top, either by structural angles or by rolling top over ¼ inch steel rod. Provide hole, gasket, and flange at low point for watertight joint and 1 inch drain line connection.

B. Pipe Sleeves: Provide pipe sleeves of one of the following:

1. Sheet-Metal: Fabricate from galvanized sheet metal; round tube closed with snaplock joint, welded spiral seams, or welded longitudinal joint. Fabricate from the following gauges: 3 inches and smaller, 20 gauge; 4 inches to 6 inches 16 gauge; over 6 inch, 14 gauge.

2. Steel-Pipe: Fabricate from Schedule 40 galvanized steel pipe; remove burrs. Provide fully welded waterstop/anchor ring fabricated from minimum 1/8 plate, extending minimum 1 inch from O.D. of sleeve, where noted in Part 3.

3. Iron-Pipe: Fabricate from cast-iron or ductile-iron pipe; remove burrs.

4. Sleeves for use with firestopping shall be fabricated in accordance with the installation instructions of the firestopping system.

PART 3 - EXECUTION

3.1 INSTALLATION OF PIPING SPECIALTIES:

A. Pipe Escutcheons: Install pipe escutcheons on each pipe penetration thru floors, walls, partitions, and ceilings where penetration is exposed to view; and on exterior of building. Secure escutcheon to pipe or insulation so escutcheon covers penetration hole, and is flush with adjoining surface.
B. Strainers: Install strainers full size of pipeline, in accordance with manufacturer's installation instructions. Install pipe nipple and shutoff full port ball valve with ¾ inch hose end and cap in strainer blow down connection. Where indicated, provide drain line from shutoff valve to plumbing drain, full size of blow down connection.

1. Provide strainers in supply line ahead of the following equipment, and elsewhere as indicated.
   a. Pumps
   b. Pressure reducing valves
   c. Temperature or pressure regulating valves
   d. Control valves

C. Dielectric Waterway: Install at each piping joint between ferrous and non-ferrous piping. Comply with manufacturer's installation instructions. Typical locations are:

   1. Water heaters
   2. Storage and pressure tanks
   3. Water conditioning equipment
   4. Changes in service piping materials
   5. Make-up connections to boilers.
   6. Make-up connections to chilled water systems.

D. Mechanical Sleeve Seals: Loosely assemble rubber links around pipe with bolts and pressure plates located under each bolt head and nut. Push into sleeve and center. Tighten bolts until links have expanded to form watertight seal.

3.2 HYDRONIC SPECIALTIES INSTALLATION:

A. Manual Air Vent: Provide manual air vents at all high points and drops in the direction of flow, of all mains and risers of the hydronic systems, at heat transfer coils, radiation and elsewhere shown and as required for system air venting.

   1. Provide enlarged air collection standpipe where large air quantities can accumulate.

   2. Use a 1/2 inch ball valve with a hose end connection, cap and chain.

B. Provide automatic air vents where shown on drawings. Provide high capacity automatic air vents at all air separators, provide an isolation valve to allow removal of all automatic air vents, provide minimum 1/4 inch soft copper tubing to a convenient drain location, and to avoid water damage.

C. Air Separator: Install inline air separators in hydronic systems pump suction lines. Run air outlet piping to compression tank with 1/4 inch per foot (2 percent) upward slope towards tank.

D. Diaphragm/Bladder-Type Compression Tank: Install diaphragm-type compression tanks in hydronic systems on floor stand as indicated. Provide Schraeder valve on air charge fitting. Vent and purge air from the water side, and charge tank with proper air charge to suit system design requirements.

   1. Provide support from the floor or structure adequate to carry twice the weight of the tank, piping connections, fittings, and weight of water assuming a full tank of water. Do not overload building components and structural members.
3.3 INSTALLATION OF FABRICATED PIPING SPECIALTIES:

A. Drip Pans: Locate drip pans under piping as indicated. Hang from structure with rods and building attachments, weld rods to sides of drip pan. Brace to prevent sagging or swaying. Connect 1" drain line to drain connection, and run to nearest plumbing drain or elsewhere as indicated.

B. Pipe Sleeves: In fire resistive construction, coordinate the use of sleeves with the firestopping system requirements. See Section 23 04 13. Do not install sleeves through structural members of work, except as detailed on drawings, or as reviewed by Architect. Install sleeves accurately centered on pipe runs. Size sleeves so that piping and insulation will have free movement in sleeve, including allowance for thermal expansion; but not less than 2 pipe sizes larger than piping run. Install length of sleeve equal to thickness of construction penetrated, and finish flush to surface; except floor sleeves where noted below. Provide temporary support of sleeves during placement of concrete and other work around sleeves, and provide temporary closure to prevent concrete and other materials from entering sleeves.

1. Interior gypsum board, plaster, and masonry partitions: Install sheet metal sleeves.

2. Interior cast in place concrete walls: Install steel pipe sleeves.

3. Interior cast in place floors: Install steel pipe sleeves with water stop/anchor ring.
   a. Extend floor sleeves in finished rooms ½ inch above level floor finish, and 2 inches above finished floor in all mechanical equipment rooms and pipe chases.

4. Below ground and exterior cast-in-place concrete or masonry: Install steel pipe sleeves with waterstop/anchor ring.

5. For core drilled solid concrete or precast concrete with blockouts, no sleeve is required, except provide sheet metal "collar" fastened and caulked to floors required to have extended sleeves.

END OF SECTION 23 05 18
SECTION 23 05 19
METERS AND GAUGES

PART 1 GENERAL

1.1 DESCRIPTION OF WORK:

A. Extent of meters and gauges required by this section is indicated on drawings and/or specified in other Division 23 sections.

B. Types of meters and gauges specified in this section include the following:

1. Temperature Gauges and Fittings:
   a. Remote Reading Dial Thermometers.
   b. Dial Type Insertion Thermometers.
   c. Thermometer Wells.
   d. Temperature Gauge Connector Plugs.

2. Pressure Gauges and Fittings:
   a. Pressure Gauges.
   b. Pressure Gauge Cocks.
   c. Pressure Gauge Connector Plugs.

3. Flow Measuring Meters:
   b. Calibrated Balance Valves.
   c. Portable Flow Meter Read-out Kits.

4. Totalizer/BTU Meter

C. Meters and gauges furnished as part of factory-fabricated equipment, are specified as part of equipment assembly in other Division 23 sections.

D. Provide gauges with dual units (standard and SI)

1.2 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacturer of meters and gauges, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Codes and Standards:

1. UL Compliance: Comply with applicable UL standards pertaining to meters and gauges.

2. ANSI and ISA Compliance: Comply with applicable portions of ANSI and Instrument Society of America (ISA) standards pertaining to construction and installation of meters and gauges.

C. Certification: Provide meters and gauges whose accuracies, under specified operating conditions, are certified by manufacturer.
1.3 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data, including installation instructions for each type of meter and gauge. Include scale range, ratings, and calibrated performance curves, certified where indicated. Submit meter and gauge schedule showing manufacturer's figure number, scale range, location, and accessories for each meter and gauge.

B. All flow measuring devices to be provided shall be reviewed and approved by the test & balance contractor and the temperature control contractor for proper scale, rangeability and function prior to submitting shop drawings. The test & balance contractor and temperature control contractor shall provide a typed letter stating this review has been completed and included with shop drawing submittals.

C. Maintenance Data: Submit maintenance data and spare parts lists for each type of meter and gauge. Include this data and product data in Maintenance Manual; in accordance with requirements of Division 23.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Manufacturer: Subject to compliance with requirements, provide products by one of the following:

1. Remote Reading Dial Thermometers:
   a. Miljoco
   b. Weiss Instruments, Inc.
   c. Pre-approved equal

2. Dial Type Insertion Thermometers and Wells:
   b. Taylor Instrument Co.
   c. Trerice (H.O.) Co.
   d. Weiss Instruments, Inc.

3. Photo Voltaic Digital Thermometers
   a. Miljoco
   b. Weiss Instruments, Inc.

4. Temperature Gauge Connector Plugs:
   a. Fairfax Company
   b. Peterson Equipment Co.
   c. Trerice

5. Pressure Gauges:
   b. Crosby
   c. Dwyer
   d. Weksler
6. Pressure Gauge Connector Plugs:
   a. Fairfax Company
   b. Peterson Equipment Co.
   c. Universal Lancaster

7. Venturi Tube Flow Measuring Elements:
   a. Gerand
   b. Presso
   c. Flow Design Inc.

8. Water Meters – Chilled Water:
   a. Onicon F 3000

9. Flow Indicator Switches:
   a. McDonnell and Miller
   b. Mueller

10. Calibrated Balancing Valves:
    b. Presso.
    c. Gerand "Balvalve Indicator"
    d. Griswold “Quickset”

11. Totalizer/BTU Meters:
    a. KEP ES762

12. Steam Meters:
    a. Veris Accelabar

2.2 REMOTE READING DIAL THERMOMETERS:

A. General: Provide remote reading dial thermometers of materials, capacities, and ranges indicated, designed and constructed for use in service indicated.
B. Type: Vapor tension.
C. Case: Drawn steel or brass, glass lens, 4-1/2 inch diameter.
D. Movement: Brass, precision geared.
E. Tubing: Bronze double braided armor over copper capillary, length to suit installation.
F. Bulb: Copper with separable socket for liquids, averaging element for air.
G. Accuracy: + or - one scale division.
H. Range: Conform to the following:
   1. Hot Water: 30 degree - 240 degree F (0 degree - 115 degree C).
   2. Chilled Water: 30 degree - 180 degree F (0 degree - 85 degree C).
3. **Air:** 30 degree - 180 degree F (0 degree - 85 degree C).

### 2.3 DIAL TYPE INSERTION THERMOMETERS:

A. **General:** Provide dial type insertion thermometers of materials, capacities, and ranges indicated, designed and constructed for use in service indicated.

B. **Type:** Bi-metal, stainless steel, shock-proof, case and stem, 1 inch diameter dial, dust and leak proof, 1/8 inch diameter stem with nominal length of 5 inch. Provide in individual case.

C. **Accuracy:** 0.5 percent of dial range.

D. **Range:** Conform to the following:

   1. **Hot Water:** 0 degrees - 220 degrees F (-10 degrees - 110 degrees C).
   2. **Chilled Water:** 25 degrees - 125 degrees (0 degrees - 85 degrees C).

### 2.4 PHOTO VOLTAIC DIGITAL THERMOMETERS:

A. **Case:** High image ABS, with photovoltaic power cell and digital readout.

B. **Range:** Selectable between -40-300 degrees F/-40-150 degrees F, displayed to 0.1 degrees.

C. **Accuracy:** 1 percent of reading or 1 degrees F, whichever is greater. Recalibratable via internal potentiometer. Not affected by ambient temperature.

D. **Ambient Light Required:** 10 lux

E. **Display Update:** 10 seconds

F. **Stem:** Compatibly with standard thermowell for piping applications, or sampling tube with flange for air duct applications.

### 2.5 THERMOMETER WELLS:

A. **General:** Provide thermometer wells constructed of brass or stainless steel, pressure rated to match piping system design pressure. Provide 2 inch extension for insulated piping. Provide cap nut with chain fastened permanently to thermometer well.

### 2.6 TEMPERATURE AND PRESSURE GAUGE CONNECTOR PLUGS:

A. **General:** Provide temperature gauge connector plugs pressure rated for 600 psig and -20°F to 300°F. Construct of brass and finish in nickel-plate, equip with ½ inch NPS fitting, with self-sealing valve core type neoprene gasketed orifice suitable for inserting 1/8 inch O.D. probe assembly from dial type insertion thermometer or pressure gauge. Equip orifice with gasketed screw cap and chain. Provide extension, length equal to insulation thickness, for insulated piping.

### 2.7 PRESSURE GAUGES:

A. **General:** Provide pressure gauges of materials, capacities, and ranges indicated, designed and constructed for use in service indicated.
B. Type: General use, 1 percent accuracy, ANSI B40.1 grade A, phospher bronze bourdon type, bottom connection.
C. Case: Drawn steel or brass, glass lens, 4-1/2inch diameter. Provide individual shock proof case.
D. Connector: Brass with 1/4inch male NPT. Provide protective syphon when used for steam service.
E. Scale: White coated aluminum, with permanently etched markings.
F. Range: Conform to the following:

1. Vacuum: 30 inches Hg - 15 psi.
2. Water: 0 - 100 psi.
3. Steam: 0 - 200 psi.

2.8 PRESSURE GAUGE COCKS:

A. General: Provide pressure gauge cocks between pressure gauges and gauge tees on piping systems. Gauge cock shall be ¼ inch female NPT on each end ball valve as specified in Section 15100 - Valves.
B. Syphon: ¼ inch straight coil constructed of brass tubing with ¼ inch male NPT on each end.
C. Snubber: ¼ inch brass bushing with corrosion resistant porous metal disc, through which pressure fluid is filtered. Select disc material for fluid served and pressure rating.

2.9 VENTURI TUBE FLOW MEASURING ELEMENTS:

A. Primary flow measuring elements shall consist of venturi tubes. Arrange piping in accordance with manufacturer's published literature. In horizontal pipes, place connections slightly above horizontal centerline of pipe.
B. Provide each primary element with integral tab, or metal tag on stainless steel wire, extending outside pipe covering on which is stamped or clearly printed in plainly visible position the following information:

1. Manufacturer's name and address.
2. Serial number of meter to which element is to be connected.
3. Name, number, or location of equipment served.
4. Specified rate of flow.
5. Multiplier (including unity, where applicable) to be applied to meter reading.
C. Provide taps with Schraeder or Hanson type fittings. Provide tap extensions to accommodate insulation.
D. Manufacturer shall certify venturi tubes for actual piping configuration. Any necessary piping changes required for certification shall be provided without cost to Owner. Insert type tubes may be furnished, provided they meet specification requirements in other respects.
E. Provide venturi with throat diameter such that specified rate of flow will register scale reading of between 20 percent and 80 percent of full scale value.
F. Venturi sizes and beta ratios shall be selected so that design flow rates shall read between 20 percent and the full scale range on a linear meter (e.g. between 10 inches and 50 inches on a 0-50 inches meter), with permanent pressure loss of not more than 25 percent of indicated flow rate differential pressure.
G. Provide venturi tubes of solid brass or bronze. Tubes larger than 2 inches shall have flanges or butt weld connections and may be cast iron or steel. Steel tubes may be fabricated or cast with cadmium or zinc-plating. Line throats of cast iron tubes with bronze and plate cast iron portion with cadmium.

H. Tubes shall be calibrated and tested by independent testing laboratory and performance data furnished with shop drawings.

I. Connections for attachment to portable flow meter hoses shall be readily accessible.

2.10 CALIBRATED BALANCE VALVES:

A. General: Provide as indicated, calibrated balance valves equipped with readout valves to facilitate connecting of differential pressure meter to balance valves. Equip each readout port with a quick connect valve designed to minimize system fluid loss during monitoring process. Provide balance valves with preformed insulation suitable for use on heating and cooling systems, and to protect balance valves during shipment.

B. Design, variable orifice type:

2. Multiple turns of handwheel from full closed to full open.
4. Schraeder type taps upstream and downstream.
5. Memory stop device to allow valve to be returned to balanced position after being closed. (Note: this does not take the place of isolation valves shown on drawings)
6. Provide slide rule type flow calculator, include in Operation and Maintenance Manual.

C. Design, valve and venturi type:

1. Ball or butterfly type valve.
2. Bubble-tight shut-off.
3. Fixed venturi, upstream of valve.
4. Schraeder type taps on venturi, upstream and downstream.
5. Memory stop device to allow valve to be returned to balanced position after being closed. (Note: this does not take the place of isolation valves shown on drawings)
6. Provide metal tag with flow curve for each valve.

2.11 FLOW METER READ-OUT KITS:

A. Provide flow meter read-out kits with bellows type differential pressure element and minimum 5 inch diameter indicating dial.

B. Design pressure elements for full scale pressure differential of 50 inches or 100 inches water gauge. Design shall incorporate rupture-proof metal beryllium or stainless steel bellows and torque tube drive requiring no lubrication. Design forged bodies for not less than 150 percent of maximum surge pressure, fully protected against surges, with full provision for venting and draining. Provide integral, adjustable pulsation dampers.

C. Dials of portable meters shall have square root scales not less than 12 inches in developed length. Dials shall read from 0 to 10 gpm to which multiplier is to be applied, as required; also provide with uniform scale reading from 0 inches to 10 inches w.g., to which multiplier of 10 to be applied (100 inches at full
scale), or from 0 inches to 5 inches w.g., to which multiplier of 10 is to be applied (50 inches at full scale).

D. Engineer and manufacture in accordance with ASME recommendations for flowmeters. Provide portable meters with overall accuracy of + 5 percent.

E. Provide flow meter with factory-fabricated carrying case with integral carrying handle. Case shall be fitted to hold meter and following accessories.

1. Two 10 feet lengths of connecting hose with suitable female connectors for connecting to venturi tube pressure tap nipples. Design hose for operating pressure of minimum of 150 percent of maximum system operating pressure.

2. Completely assembled 3-value manifold with 2 block valves and vent and drain valves shall be piped and mounted on base, which shall be designed for use laying flat on stationary base.

3. Bound set of descriptive bulletins, installation and operating instructions, parts list, and set of curves showing flow verses pressure differential for each orifice or venturi tube with which meter is to be used.

4. Metal instruction plate, secured inside cover, illustrating use of meter. Deliver meter with case to Owner.

PART 3 EXECUTION

3.1 INSPECTION:

A. Examine areas and conditions under which meters and gauges are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION OF THERMOMETERS:

A. General: Install thermometers in vertical upright position, and tilted so as to be easily read by observer standing on floor.

B. Locations: Install in the following locations where shown on details, and elsewhere as indicated:

1. At inlet and outlet of each hydronic boiler and chiller.
2. At inlet and outlet of each hydronic coil in air handling units.
3. At inlet and outlet of each hydronic heat exchanger.
4. At inlet and outlet of each hydronic heat recovery unit.
5. At inlet and outlet of each storage tank.
6. In discharge duct or plenum of air handling units.

C. Remote Reading Dial Thermometers: Install on control panels as indicated. Run tubing between panel and thermometer bulb, adequately supported to prevent kinks. Select tubing length so as to not require coiling of tubing.

D. Thermometer Wells: Install in piping tee where indicated, in vertical upright position. Fill well with oil or graphite, secure cap.

E. Temperature Gauge Connector Plugs: Install in piping tee where indicated, located on pipe at most readable position. Secure cap. Provide portable temperature gauge for each plug connection.
3.3 INSTALLATION OF PRESSURE GAUGES:

A. General: Install pressure gauges in piping tee with pressure gauge cock, located on pipe at most readable position.

B. Locations: Install in the following locations, and elsewhere as indicated:

1. At suction and discharge of each pump.
2. At discharge of each pressure reducing valve.
3. At water service outlet.
4. At inlet and outlet of water cooled condensers and refrigerant cooled chillers.

C. Pressure Gauge Cocks: Install in piping tee with snubber. Install syphon for steam pressure gauges.

D. Pressure Gauge Connector Plugs: Install in piping tee where indicated, located on pipe at most readable position. Secure cap. Provide portable pressure gauge for each plug connection.

3.4 INSTALLATION OF FLOW MEASURING METERS:

A. General: Install flow measuring meters/calibrated balance valves on piping systems located in accessible locations at most readable position.

B. Locations: Install in the following locations, and elsewhere as indicated.

1. At discharge of each pump.
2. At inlet of each hydronic coil.

C. Calibrated Balance Valves: Install on piping with readout valves in vertical upright position. Maintain minimum length of straight unrestricted piping equivalent to 3 pipe diameters upstream of valve.

D. Venturi or other flow measuring devices are required wherever water balancing is required.

3.5 INSTALLATION OF P/T PORTS:

A. Provide ports at mains where branches split or converge to trouble shoot system.

3.6 ADJUSTING AND CLEANING:

A. Adjusting: Adjust faces of meters and gauges to proper angle for best visibility.

B. Cleaning: Clean windows of meters and gauges and factory-finished surfaces. Replace cracked or broken windows, repair any scratched or marred surfaces with manufacturer's touch-up paint.

END OF SECTION 23 05 19
PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. This Section includes general duty valves common to most mechanical piping systems.

B. Valves tags and charts are specified in Division 23 Section "Mechanical Identification."

1.2 SUBMITTALS:

A. Product Data: including body material, valve design, pressure and temperature classification, end connection details, seating materials, trim material and arrangement, dimensions and required clearances, and installation instructions. Submittals must indicate compliance with applicable MSS (Manufacturer Standardization Society) standards.

1.3 QUALITY ASSURANCE:

A. Single Source Responsibility: Comply with the requirements specified in Division-15 Section "Basic Mechanical Requirements," under "Product Options."

B. MSS Standard Practices: Comply with the following standards for valves:

   1. MSS SP-45: Bypass and Drain Connection Standard
   2. MSS SP-67: Butterfly Valves
   3. MSS SP-70: Cast Iron Gate Valves, Flanged and Threaded Ends
   4. MSS SP-71: Cast Iron Swing Check Valves, Flanged and Threaded Ends
   5. MSS-SP-110: Ball Valves with Flanged or Butt-Welding Ends for General Service
   6. MSS SP-78: Cast Iron Plug Valves, Flanged and Threaded Ends
   7. MSS SP-80: Bronze Gate, Globe Angle and Check Valves
   8. MSS SP-84: Steel Valves - Socket Welding and Threaded Ends
   9. MSS SP-85: Cast Iron Globe and Angle Valves, Flanged and Threaded Ends
   10. MSS SP-92: MSS Valve User Guide

C. Solenoid valves shall be UL listed, FM and CSA approved.

1.4 DELIVERY, STORAGE, AND HANDLING:

A. Preparation for Transport: Prepare valves for shipping as follows:

   1. Ensure valves are dry and internally protected against rusting and galvanic corrosion.
   2. Protect valve ends against mechanical damage to threads, flange faces, and weld end preps.
   3. Set valves in best position for handling. Globe valves shall be closed to prevent rattling; ball and plug valves shall be open to minimize exposure of functional surfaces; butterfly valves shall be shipped closed or slightly open; swing and silent check valves shall be blocked in either closed or open position.

B. Storage: Use the following precautions during storage:

   1. Valves shall be stored and protected against all dirt, debris and foreign material at all times.
2. Do not remove valve end protectors unless necessary for inspection; then reinstall for storage.

3. Protect valves against weather. Where practical store valves indoors. Maintain valve temperature higher than the ambient dew point temperature. If outdoor storage is necessary, support valves off the ground or pavement and protect in watertight enclosures.

C. Handling: Valves whose size requires handling by crane or lift shall be slung or rigged to avoid damage to exposed valve parts. Handwheels and stems, in particular, shall not be used as lifting or rigging points.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Manufacturer: Subject to compliance with requirements, provide products by the manufacturers listed.

1. Ball Valves:

   a. Conbraco (Apollo)
   b. Milwaukee
   c. Nibco
   d. Watts
   e. Jomar
   f. Dynaquip
   g. Hammond
   h. James Bury
   i. Worcester

2. Non-Lubricated Eccentric Plug Valves:

   a. Keystone/Tyco
   b. DeZurik
   c. Milliken

3. Lubricated Plug Valves:

   a. Nordstrom
   b. Powell
   c. Walworth

4. Butterfly Valves:

   a. Keystone/Tyco
   b. Nibco
   c. Crane
   d. Dezurik
   e. Fisher
   f. Hammond
   g. James Bury
   h. Milwaukee
   i. Posi-Seal
   j. Victaulic

5. Swing Check Valves
6. **Non-Slam Check Valves:**
   
   a. Centerline
   b. Keystone
   c. Metraflex
   d. Techno Corporation
   e. Nibco
   f. Val-Matic
   g. Milwaukee
   h. Stockham
   i. Golden Anderson

7. **Lift Check Valves:**
   
   a. Conbraco
   b. Metraflex
   c. Milwaukee
   d. Nibco
   e. Stockham

### 2.2 VALVE FEATURES:

A. **General:** Comply with MSS-92 1980 "Valve Users Manual".

B. **Valve Design:** Valves shall have rising stem, or rising stem outside screw and yoke design; except, non-rising stem valves may be used where headroom prevents full operation of rising stem valves.

C. **Sizes:** Unless otherwise indicated, provide valves of same size as upstream pipe size. (Control valves shall be sized for required flow.)

D. **Operators:** Provide the following special operator features:
   
   1. **Handwheels,** fastened to valve stem for valves other than quarter turn.
   
   2. **Lever Handle** on quarter turn valves 6 inch and smaller, except plug valves. Provide a wrench for every plug valve.
   
   3. **Chainwheel operators** for valves 2-1/2 inch and larger that are installed 96 inches or higher above finished floor elevation. Provide chains to an elevation of 6’-0” above finished floor elevation.
   
   4. **Worm gear operators** of an enclosed weather-proof design shall be provided on all quarter turn valves 8 inches and larger.

E. **Extended Stems:** Where insulation is indicated or specified, provide extended stems to allow full operation of the valve without interference by the insulation.

F. **Bypass and Drain Connections:** Comply with MSS SP-45.

G. **End Connections:** As specified in the individual valves specifications.

1. **Threads:** Comply with ANSI B2.1.

   a. Caution: Where soldered end connections are used, use solder having a melting point below 840 degrees F for gate, globe, and check valves and below 421 degrees F for ball valves.

2.3 BALL VALVES:

A. Ball Valves – 1 inch and Smaller: 150 WSP, 600 WOG, rated for 150 PSI at 350 degrees F, two piece end entry body style, bronze body conforming to ASTM B584, full port solid bored-hole, stainless steel ball and stem, 15 percent glass reinforced PTFE seats, PTFE packing, adjustable packing nut blow-out proof stem, vinyl covered steel handle. Provide solder ends or threaded ends to match piping system. Apollo 77-200

B. Ball Valves 1-1/4 inch through 2 inches and for all silver soldered or brazed lines: ANSI B16.34, 150 WSP, 600 WOG, rated for 150 PSI at 350 degrees F. Three piece body style, bronze body conforming to ASTM B584, full port, solid, bored-hole stainless steel ball and stem of ASTM A276 type 316, 15 percent glass reinforced RTFE seats, RTFE packing and blow out proof stem, vinyl coated steel handle. Provide solder ends or threaded ends to match piping material system. Apollo 82-200.

C. Ball valve options/accessories: Provide the following as required or as specifically indicated:
   1. Tee handle for tight fit applications (within enclosures, etc.).
   2. Locking handle.
   3. Drain.
   4. Stem extension.
   5. Mounting pads.

2.4 ECCENTRIC PLUG VALVES:

A. 2 inches and Smaller: 125 psi, cast iron body, straightway pattern, EPDM or C11REncapsulated Eccentric plug, tight shut-off seals, square head, threaded ends. Provide memory stop feature. Dezurik PEC

B. 2-1/2 inches and Larger Sizes: 125 psi, cast iron body, straightway pattern, EPDM or C11R Encapsulated Eccentric plug, lever actuators, except handwheels where indicated, and flanged ends. Provide memory stop feature. Dezurik PEC

2.5 GLOBE VALVES:

A. Plumbing Systems (2-1/2 inches and smaller): MSS SP-80 Class 150, body, bonnet and bonnet ring, cast bronze ASTM B-62, Teflon disc, copper-silicon bronze stem, non-asbestos teflon impregnated stem packing, union bonnet and malleable iron handle. Stockham Fig. B-22/B-24
2.6 **BUTTERFLY VALVES:**

A. Hydronic Service Butterfly Valves - 2-1/2 inches to 12 inches: MSS SP-67, cast iron body conforming to ASTM A126 class B, aluminum bronze ASTM B148 disc, single piece 416 stainless steel stem, EPDM seat (-40°F to 250°F), upper and lower bronze bearing, non-metallic bushing and stem seal, ANSI class 125 flange, rated for 200 psi pressure differential, 200 psi drop-tight shut off dead end service, with downstream flange removed. Provide extended neck for 2 inches thick insulation. All valves shall be factory tested to 110 percent of pressure rating. All butterfly valves shall be full lugged body, drilled and tapped. Shall be capable of dead-end shut-off and full-rated pressure without the need for downstream blind flange. Infinite position lever with memory stop for 2”-5”. 6” through 12” use self locking worm gear with adjustable limit stops and position indicator.

Keystone Fig.222

2.7 **CHECK VALVES:**

A. Swing Check Valves - 2-1/2 Inch and Smaller: MSS SP-80; Class 125/150 WSP 200/300, cast bronze body and cap conforming to ASTM B62, bronze, horizontal swing design, Y-pattern, with a bronze disc, stainless steel pin and having threaded or solder ends. Class 150 valves meeting the above specifications may be used where pressure requires or Class 125 are not available.

B. Swing Check Valves - 2-1/2 to 3 Inch: MSS SP-71; Class 125/250 (Class 175 FM approved for fire protection piping systems), cast iron body and bolted cap conforming to ASTM A126, Class B; horizontal swing, with a bronze disc or cast iron disc with bronze disc ring, and flanged ends. Valve shall be capable of being refitted while the valve remains in the line. For sewage ejector and sump pump discharge swing check valves 2-1/2 inches and larger, provide outside lever with weight or spring to assist disc to close rapidly.

C. Non-Slam Check Valves - 2 Inch and smaller: Bronze body, 200 psi @ 250 degrees F., threaded ends, resilient seats, center guided spring loaded disk.

D. Non-Slam Check Valves - 2-1/2 Inch and Larger: Class 250 cast iron or stainless steel body, replaceable lapped bronze seat and balanced twin bronze flappers or bronze center guided disc and stainless steel trim. Valve shall be designed to open and close at approximately one foot differential pressure. Twin flappers or center guided disc shall be loaded with a stainless steel spring to assure even non-slam checking action. Seals shall be EPDM.

E. Lift Check Valves 2 Inch and Smaller: Class 125, cast bronze body and cap conforming to ASTM B62, horizontal or angle pattern, lift type valve, with stainless steel spring, bronze disc holder with renewable "Teflon" disc, and threaded ends. Valve shall be capable of being refitted and ground while the valve remains in the line.

2.8 **DRAIN VALVES:**

A. For HVAC and plumbing hydronic systems provide ball valve with threaded hose end, and cap with chain. Stainless steel ball and stem.

Apollo Fig. 78-100/78-200 Series

2.9 **SOLENOID VALVES:**
A. Solenoid valves shall consist of a solenoid (electro-magnet) with its core and a valve body containing one or more orifices. The solenoid shall be mounted directly on the valve body.

B. Response time from fully open or closed to fully closed or open shall be slow acting.

C. Solenoid valves shall be 2 way type valves.

D. Solenoid valves shall be normally open or normally closed operation as required for proper operation of the system for protection against freeze, fire and safety.

E. Solenoid enclosures shall meet the ICS-6 ANSI/NEMA standard and UL standard 429, 508 and/or 1002 as follows:

1. Type 1: General Purpose.
2. Type 2: Drip proof.
3. Type 3 and 3S: Raintight, Dust tight and sleet (ice) resistant.
4. Type 3R: Rainproof, sleet (ice) resistant
5. Type 4: Watertight and dust tight.
6. Type 4X: Watertight, Dust tight and Corrosion resistant.
7. Type 6: Submersible.
8. Type 6P: Submersible, prolonged submersion at a limited depth.
9. Type 7: Explosion proof, Class I, Division 1, Group A (acetylene); B (hydrogen); C (ethyl-ether vapors, ethylene or cyclopropane); D (gasoline, hexane, naphtha, benzene, butane, propane, alcohol, acetone, benzol, lacquer, solvent vapors or natural gas).
10. Type 9: Dust-ignition proof, Class II, Group E (metal dust); F (carbon black coal or coke dust); G (flour starch or grain dust).
11. Operating temperatures shall range from 185 degrees F to 842 degrees F for T1 through T6 code numbers.

F. Minimum ambient temperature limitation of 32 degrees F (0 degrees C) for any valve which contains water or water vapor and 0 degrees F (-18 degrees C) where freezing water is not a factor. (Special construction for ambient temperature down to -40 degrees F (-40 degrees C). Maximum ambient temperature limitation of 180 degrees F (82 degrees C).

G. Parts in contact with fluid shall be brass, bronze, or stainless steel; core tube, 305 stainless steel; core and plug nut, 430 F stainless steel; Seal-BUNA "N"; shading coil-copper; disc-BUNA "N" and Nylon; Spring, 302 stainless steel (General Service).

H. Manual reset safety shut-off valve shall open manually and close upon interruption of current.

I. Electric current shall be AC of voltage shown on Division 16 drawings.

2.10 MOTORIZED VALVE ACTUATORS:

A. Electric Valve Actuators

1. The valve actuator shall consist of a 120 volt, single phase, permanent split capacitor, reversible type electric motor which drives a compound epicyclic gear. A manual override handwheel shall be integral to the unit. The electric actuator shall have visual mechanical position indication, readable from a distance of 25 feet, showing output shaft and valve position. Unit shall be capable of mounting directly to butterfly valve without brackets and adapters.

2. The actuator shall have an integral terminal strip, for wiring to power supplies. Cable entry shall be by means of two (2) 1 inch NPT threaded connections. Cable entries shall have UL
recommended gland stops within the NPT hole to prevent glands from being screwed in too far and damaging cable.

3. The actuator shall be constructed to withstand high shock and vibrations without operations failure. The actuator cover shall have captive bolts to eliminate loss of bolts when removing the cover from the base. One copy of the wiring diagram shall be provided with the actuator.

4. Actuators with 600 in/lbs or more output torque shall be two adjustable factory calibrated mechanical torque limit switches of the single pole, double-throw type. Motor rotor shaft shall run in ball bearings at each end of the motor.

5. The actuator housing shall be manufactured to NEMA IV Standards and UL recognized.

6. The environmental temperature range of the actuator shall be -30 degrees C. to +60 degrees C. (-20 degrees F. to +140 degrees F.).

7. For two position service, the actuator shall be rated at a 20 percent duty cycle (i.e. 12 minutes extended duty in every hour, or alternatively; one complete cycle every two minutes). For frequent cycling and modulating service, the actuator shall be rated for continuous duty, capable of operating 100 percent of the time at an ambient temperature of 40 degrees C.

8. The actuator shall have a permanently lubricated, self-locking gear train. Motor brakes shall not be required to maintain desired valve position. Levers or latches shall not be required to engage or disengage the manual override. Mechanical travel stops, adjustable to 15 degrees in each direction of 90 degrees rotation, shall be standard, as well as two adjustable travel limit switches with electrically isolated contacts. Additional adjustable switches shall be provided where required to meet the sequence of operation.

9. The motor shall have Class B insulation capable of withstanding locked rotor for 25 seconds without overheating. Wiring shall also be Class B insulation. An auto-reset thermal cut-out protector shall be embedded in the motor windings. The motor shall be UL recognized and CSA approved. Disassembly of gears shall not be required to remove the motor.

10. Materials

   a. The electric actuator shall have a pressure die-cast, hard anodized aluminum base and cover. The compound gear shall be made of die-cast, hard anodized aluminum or steel. An alloy steel worm gear shall be provided for manual override and torque limiting. Bearings for gears shall be of the ball and needle type; bronze bearings shall be used on the shafting parts.

11. Electric Valve Actuator Accessories

   a. Provide thermostatically controlled heaters for all exterior valves.

   b. Provide potentiometer or 4-20 MA-transmitter for providing continuous feedback of actuator position where required to meet the sequence of operations.

   c. Provide an electronic servo amplifier and speed control module capable of accepting a 0-5K ohm, 4-20mA DC or other input signal for all modulating control valves.

   d. For all valves with electric actuators, provide an electric power fail-safe unit in a NEMA I/IV enclosure to drive the actuator open or closed upon failure of the main power supply.
The unit shall be capable of operating the actuator up to 20 cycles without the main power supply being available.

PART 3 - EXECUTION

3.1 EXAMINATION:

A. Install valves in accordance with manufacturers instructions.

B. Examine valve interior through the end ports, for cleanliness, freedom from foreign matter and corrosion. Remove special packing materials, such as blocks used which prevents disc movement during shipping and handling.

C. Actuate valve through an open-close and close-open cycle. Examine functionally significant features, such as guides and seats made accessible by such actuation. Following examination, return the valve closure member to the position in which it was shipped.

D. Examine threads on both the valve and the mating pipe for form (out-of-round or local indentation) and cleanliness.

E. Examine mating flange faces for conditions which might cause leakage. Check bolting for proper size, length, and material. Check gasket material for proper size and material, and for freedom from defects and damage.

F. Prior to valve installation, examine the piping for cleanliness, freedom from foreign materials, and proper alignment.

G. Locate valves in accessible locations with adequate clearance around hand wheels or levers for easy operation.

H. Install isolation valves within 5 feet of the equipment or appliance served.

3.2 VALVE SELECTION:

A. Selection of Valve Ends (Pipe Connections): Except as otherwise indicated, select valves with the following ends or types of pipe/tube connections:

1. Copper Tube Size 1/1/2 Inch and Smaller: Solder ends, except in heating hot water and low pressure steam service which shall have threaded ends.

2. Copper Tube Size 2 Inch and Larger: Brazed ends, except in heating hot water and low pressure steam service which shall have threaded ends.

3. Steel Pipe Sizes 2 Inch and Smaller: Threaded or grooved-end.

4. Steel Pipe Sizes 2-1/2 Inch and Larger: Flanged or grooved end.

5. At all piping hot taps provide a gate valve with the hot tap and a butterfly valve for shut-off service. Hot taps shall be provided only where approved by the Engineer.

3.3 VALVE INSTALLATIONS:
Valve Application Table

(Where sizes overlap, contractor has choice of either type)

<table>
<thead>
<tr>
<th>SERVICE</th>
<th>VALVE TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>HVAC Hydronic Piping; 3” and smaller</td>
<td>Ball Valve</td>
</tr>
<tr>
<td>HVAC Hydronic Piping; 2-1/2” and larger</td>
<td>Butterfly Valve</td>
</tr>
<tr>
<td>HVAC Hydronic Pressure Reducing Valve Bypass; all sizes</td>
<td>Globe Valve</td>
</tr>
<tr>
<td>HVAC Hydronic Balancing valve; 2” and smaller</td>
<td>Calibrated Balancing Valve</td>
</tr>
<tr>
<td>HVAC Hydronic Balancing Valve; 2-1/2” and larger</td>
<td>Venturi with Butterfly Valve</td>
</tr>
<tr>
<td>HVAC &amp; Plumbing Check Valves; 2” and smaller</td>
<td>Swing Check</td>
</tr>
<tr>
<td>HVAC &amp; Plumbing Pump Discharge Check Valve;</td>
<td>Non-Slam Spring Loaded</td>
</tr>
</tbody>
</table>

A. Locate valves for easy access and provide separate support where necessary.

B. Install valves and unions for each fixture and item of equipment in a manner to allow equipment removal without system shut-down. Unions are not required on flanged devices.

C. Install 3-valve bypass around each pressure reducing valve using throttling type valves.

D. Gate and globe valves shall be installed with the stem in the upright position. In overhead horizontal piping, ball valves shall be installed with the handle in the side or bottom of the piping. Butterfly valves shall be installed with the stem within 45 degrees of the horizontal position. The handle of quarter turn valves shall open in the direction of flow. Quarter turn valves with hand wheels or chain wheels shall be located so that the position indicator is visible from the floor without the use of a ladder or climbing on equipment or piping.

E. Installation of Check Valves: Install for proper direction of flow as follows:

1. Swing Check Valves: Install in horizontal position with hinge pin level.
2. Wafer Check Valves: Install between 2 flanges in horizontal or vertical upward flow position.
3. Lift Check Valve: Install in piping line with stem upright and plumb.

3.4 SOLDER CONNECTIONS (1-1/2” AND SMALLER):

A. Cut tube square and to exact lengths.

B. Clean end of tube to depth of valve socket, using steel wool, sand cloth, or a steel wire brush to a bright finish. Clean valve socket in same manner.

C. Apply proper soldering flux in an even coat to inside of valve socket and outside of tube.

D. Open gate and globe valves to fully open position.

E. Remove the cap and disc holder of swing check valves with composition discs.
F. Insert tube into valve socket making sure the end rests against the shoulder inside valve. Rotate tube or valve slightly to insure even distribution of the flux.

G. Apply heat evenly to outside of valve around joint until solder will melt upon contact. Feed solder until it completely fills the joint around tube. Avoid hot spots or overheating the valve. Once the solder starts cooling, remove excess amounts around the joint with a cloth or brush.
3.5 **BRAZED CONNECTIONS (2” AND LARGER):**

A. Protect valves from temperatures which exceed the valve material temperature limitations as recommended by the valve manufacturer.

B. Disassemble 3 piece ball valves prior to brazing.

3.6 **THREADED CONNECTIONS:**

A. Note the internal length of threads in valve ends, and proximity of valve internal seat or wall, to determine how far pipe should be threaded into valve.

B. Align threads at point of assembly.

C. Apply appropriate tape or thread compound to the external pipe threads (except where dry seal threading is specified).

D. Assemble joint wrench tight. Wrench on valve shall be on the valve end into which the pipe is being threaded.

3.7 **FLANGED CONNECTIONS:**

A. Align flanges surfaces parallel.

B. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly using a torque wrench.

3.8 **BUTTERFLY VALVE MOTORIZED ACTUATORS:**

A. Coordinate with the control system installer to set up all end switches, pilot valves, and control panels.

B. Provide electric valve actuator power in accordance with electrical specifications.

C. Set travel stops as recommended by the valve manufacturer or as indicated.

D. Locate pilot positioners and valve position indicators so that they will be visible from the floor or roof surface, without the need of a ladder or climbing over equipment and piping.

3.9 **FIELD QUALITY CONTROL:**

A. Testing: After piping systems have been tested and put into service, but before final adjusting and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks; replace valve if leak persists.

3.10 **ADJUSTING AND CLEANING:**

A. Cleaning: Clean mill scale, grease, and protective coatings from exterior of valves and prepare to receive finish painting or insulation.

**END OF SECTION 23 05 23**
SECTION 23 05 29
SUPPORTS AND ANCHORS

PART 1 - GENERAL

1.1 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of supports and anchors, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Codes and Standards:

1. Regulatory Requirements: Comply with applicable plumbing codes pertaining to product materials and installation of supports and anchors.

2. NFPA Compliance: Hangers and supports shall comply with NFPA standard No. 13 when used as a component of a fire protection system and NFPA Standard No. 14 when used as a component of a standpipe system.

3. UL and FM Compliance: Hangers, supports, and components shall be listed and labeled by UL and FM where used for fire protection piping systems.

4. Duct Hangers: SMACNA Duct Manuals

5. MSS Standard Compliance:

a. Provide pipe hangers and supports of which materials, design, and manufacture comply with MSS SP-69.

1.2 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data, including installation instructions for each type of support and anchor. Submit pipe hanger and support schedule showing Manufacturer's figure number, size, location, and features for each required pipe hanger and support.

B. Shop Drawings: Submit manufacturer's assembly-type shop drawings for each type of support and anchor, indicating dimensions, weights, required clearances, and methods of assembly of components.

C. Product certificates signed by the manufacturer of hangers and supports certifying that their products meet the specified requirements.

D. Maintenance Data: Submit maintenance data and parts list for each type of support and anchor. Include this data, product data, and shop drawings in maintenance manual; in accordance with requirements of Division 15.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Manufacturer: Subject to compliance with requirements, provide products by one of the following:

1. Pipe Hangers and Supports:
a. B-Line Systems Inc.  
b. Grinnell  
c. PHD Manufacturing, Inc.  
d. Michigan  
e. Tolco  

2. Saddles, Shield and Thermal Shield Inserts:  
   a. ANVIL International  
   b. Pipe Shields, Inc.  
   c. B-Line  
   d. Insulated Saddle Shield Insert Product Inc.  

3. Roof Equipment Supports:  
   a. Custom Curb, Inc.  
   b. Pate Co.  
   c. Thycurb Div.; Thybar Corp.  
   d. Vent Products, Inc.  

4. Concrete Inserts and Anchors:  
   a. Unistrut Metal Framing Systems  
   b. Power-Strut  
   c. ITW Ramset/Red Head  
   d. Hilti  
   e. B-Line  

2.2 PIPE HANGERS & SUPPORTS:  

A. Hangers and support components shall be factory fabricated of materials, design, and manufacturer complying with MSS SP-69.  
   1. Components shall have galvanized coatings where installed for piping and equipment that will not have field-applied finish.  
   2. Pipe attachments shall have nonmetallic coating for electrolytic protection where attachments are in direct contact with copper tubing.  

B. Adjustable Clevis Hanger: MSS Type.  
   1. Steel Pipe, size 3/8" thru 30", Type 1.  
   2. Non-insulated Copper Pipe, size 1/2" thru 4", Type 1. (PVC Coated)  

C. Adjustable Swivel Ring for Non-insulated Pipe: MSS Type.  
   1. Steel Pipe, size 1/2" thru 8", Type 7.  
   2. Copper Pipe, size 1/2" thru 4", Type 7 (PVC Coated)
D. Pipe Clamps: MSS Type.
   1. Steel Pipe, size 3/4” thru 24”, Type 8.
   2. Copper Pipe, size 1/2” thru 4”, Type 8 (PVC Coated).

E. U Bolts: MSS Type.
   1. Steel Pipe, size 1/2” thru 30” Type 24
   2. Copper Pipe, size 1/2” thru 8”, Type 24 (PVC Coated).

F. Straps: MSS Type 26.

G. Pipe Stanchion Saddle: MSS Type 37.

H. Yoke & Roller Hanger: MSS Type 43

I. Hanger Rods: Continuous threaded steel, sizes as specified.

J. Hangers:
   1. Hot Pipes:
      a. 1/2” through 1-1/2”: Adjustable wrought steel ring.
      b. 2” through 5”: Adjustable wrought steel clevis.
      c. 6” and Over: Adjustable steel yoke and cast iron roll.
   2. Cold Pipes:
      a. 1/2” through 1-1/2”: Adjustable wrought steel ring.
      b. 2” and Over: Adjustable wrought steel clevis.
   3. Multiple or Trapeze: Structural steel channel (with web vertical and engineered for the specific applications), with welded spacers and hanger rods. Provide cast iron roll and base plate for hot pipe sizes six inches and over. Provide hanger rods one size larger than for largest pipe in trapeze. If the deflection at center of trapeze exceeds 1/360 of the distance between the end hangers, install an additional hanger at mid-span or use a larger channel.

K. Wall Supports for Horizontal Steel Pipe:
   1. ½ inch through 4inches: Offset or straight j-hook.
   2. 4 inches and Over: Welded steel bracket Type 31, 32 or 33 and wrought steel clamp. Provide adjustable steel yoke and cast iron roll Type 44 for hot pipe 200°F and over and for sizes six inches and over.

L. Supports for Vertical Pipe: Steel riser clamp. Type 8.

M. Upper Attachments:
   1. For attaching hanger rods to structural steel I-beams:
      a. Provide adjustable beam clamp, MSS-Type 21. Attach to bottom flange of beam.
2. For attaching hanger rods to bar joists:
   a. When bottom chord is constructed of structural steel angles, provide square washer. Place hanger rod between backs of the two angles and support with the washer and dual locking nuts on top of the angles. Spot weld washer to angles.
   b. When bottom chord is constructed of round bars, provide Elcen No. 137 bar joint washer or equal.

2.3 CONCRETE INSERTS AND ANCHORS:

A. Inserts: Case shall be of galvanized carbon steel with square threaded concrete insert nut for hanger rod connection; top lugs for reinforcing rods, nail holes for attaching to forms. This type of upper attachment is to be used for all areas having poured in place concrete construction.
   1. Size inserts to suit threaded hanger rods.

B. Provide fasteners attached to concrete ceilings that are vibration and shock resistant. Provide hangers for piping attached to concrete construction with one of the following types.
   1. Concrete insert per MSS SP 69, Type 18.
   2. Powder driven fasteners subject to approval of Architect and Structural Engineer. Each fastener shall be capable of holding a test load of 1000 pounds whereas the actual load shall not exceed 50 pounds.
   3. Self-drilling expansion shields. The load applied shall not exceed one-fourth the proof test load required.
   4. Machine bolt expansion anchor. The load applied shall not exceed one-fourth the proof test load required.

C. Anchors: Carbon steel, zinc plated and coated with a clear chromate finish when exposed to view (i.e. lab corridors, basement labs). Installation shall be in holes drilled with carbide-tipped drill bits or by use of self-drilling anchors.
   1. Provide anchors suitable for the location of installation and designed to withstand all forces and movements acting in the anchor. Manufacture pipe anchors in accordance with MSS SP 69. Provide a safety factor of four for the anchor installation.

2.4 SADDLES AND THERMAL SHIELD INSERTS:

A. Protection Saddles: MSS Type 39; fill interior voids with segments of insulation matching adjoining insulation.

B. Protection Shields: MSS Type 40; 180 degrees arc, galvanized steel, minimum 12 inches long, to prevent crushing of insulation.

C. Thermal Shield Inserts: Provide 100-psi minimum compressive strength, waterproof, asbestos free calcium silicate, encased with a sheet metal enclosure. Insert and shield shall cover the entire circumference or the bottom half circumference of the pipe as required by Part 3 of this Specification, and shall be of length recommended by the manufacturer for pipe size and thickness of insulation. For cold piping, calcium silicate shall extend beyond the sheet metal shield to allow overlap of the vapor...
PART 3 EXECUTION

3.1 INSPECTION:
A. Examine areas and conditions under which supports and anchors are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 PREPARATION:
A. Proceed with installation of hangers, supports and anchors only after required building structural work has been completed in areas where the work is to be installed. Correct inadequacies including (but not limited to) proper placement of inserts, anchors and other building structural attachments. Review Structural Drawings to obtain structural support limitations.

B. Prior to installation of hangers, supports, anchors and associated work, Installer shall meet at project site with Contractor, installer of each component of associated work, inspection and testing agency representatives (if any), installers of other work requiring coordination with work of this section and Architect/Engineer for purpose of reviewing material selections and procedures to be followed in performing the work in compliance with requirements specified. Provide Shop Drawing showing method and support locations from structure.

3.3 INSTALLATION OF BUILDING ATTACHMENTS:
A. Install building attachments within concrete or on structural steel. Space attachments within maximum piping span length indicated in MSS SP-69. Install additional attachments at concentrated loads, including valves, flanges, guides, strainers, expansion joints, and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten insert to forms. Where concrete with compressive strength less than 2500 psi is indicated, install reinforcing bars through openings at top of inserts.

B. New Construction:
1. Use inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams wherever practicable.

2. Set inserts in position in advance of concrete work. Provide reinforcement rod in concrete for inserts carrying pipe over 4 inches or ducts over 60 inches wide.

3. Where concrete slabs form finished ceiling, finish inserts flush with slab surface.

4. Where inserts are omitted drill through concrete slab from below and provide rod with recessed square steel plate and nut above slab if construction above permits.

3.4 INSTALLATION OF HANGERS AND SUPPORTS:
A. Install hangers, supports, clamps and attachments to support piping properly from building structure; comply with MSS SP-69. Arrange for grouping of parallel runs of horizontal piping to be supported together on field fabricated, heavy-duty trapeze hangers where possible. Install supports with maximum spacings complying with MSS SP-69. Where piping of various sizes is supported together by trapeze barrier. Where piping 4 inches and larger is supported on trapeze or pipe rollers, provide double thickness shields. For piping 12 inches and over, provide 600 psi calcium silicate structural insert.
hangers, space hangers for smallest pipe size or install intermediate supports for smaller diameter pipe. Do not use wire or perforated metal to support piping, and do not support piping from other piping.

B. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers and other accessories.

C. Support fire-water piping independently from other piping systems.

D. Prevent electrolysis and abrasion in support of copper tubing by use of hangers and supports which are plastic coated, or with EPDM isolation strips. Duct tape or copper coated hangers are not acceptable.

E. Install hangers and supports to allow controlled movement of piping systems, to permit freedom of movement between pipe anchors, to facilitate action of expansion joints, expansion loops, expansion bends and similar units and within 1'-0" of each horizontal elbow.

F. Install hangers within 1'-0" of control valves.

G. Load Distribution: Install hangers and supports so that piping live and dead loading and stresses from movement will not be transmitted to connected equipment.

H. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes, and so that maximum pipe deflections allowed by ANSI B31.9 Building Services Piping Code is not exceeded.

I. Insulated Piping: Comply with the following installation requirements.

1. Clamps: Attach clamps, including spacers (if any), to piping with clamps projecting through insulation; do not exceed pipe stresses allowed by ANSI B31.

2. Saddles: Install Protection saddles where supported by pipe rollers. Fill interior voids with segments of insulation that match adjoining pipe insulation.

3. Shields: Install galvanized steel protection shields, on all insulated piping 2 inches and less, except where required to be clamped. Where necessary to prevent dislocation, strap shield to pipe with wire ties or "Zip Strips".

4. Thermal Inserts: Provide thermal shield inserts at all supports for all insulated piping over 2 inches and for all piping required to be clamped. Provide 180 percent inserts at clevis and roller hangers. Provide 360 percent inserts for all trapeze and clamped supports.

J. Install horizontal hydronic and steam piping with the following minimum rod sizes and maximum spacing:

<table>
<thead>
<tr>
<th>SIZE (NPS)</th>
<th>MAX. SPAN IN FEET</th>
<th>MIN. ROD SIZE-INCHES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Steel</td>
<td>Copper</td>
</tr>
<tr>
<td>1</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>1-1/2</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>3</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>14</td>
<td>12</td>
</tr>
</tbody>
</table>
K. Install steel natural gas piping with the following minimum rod size and maximum spacing:

<table>
<thead>
<tr>
<th>SIZE (NPS)</th>
<th>MAX. SPAN IN FEET</th>
<th>MIN. ROD SIZE - INCHES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2</td>
<td>6</td>
<td>3/8</td>
</tr>
<tr>
<td>3/4 TO 1</td>
<td>8</td>
<td>3/8</td>
</tr>
<tr>
<td>1-1/4</td>
<td>10</td>
<td>3/8</td>
</tr>
<tr>
<td>1-1/2</td>
<td>10</td>
<td>3/8</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
<td>3/8</td>
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<tr>
<td>3</td>
<td>10</td>
<td>½</td>
</tr>
<tr>
<td>5</td>
<td>19</td>
<td>5/8</td>
</tr>
<tr>
<td>6</td>
<td>21</td>
<td>3/4</td>
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<tr>
<td>8</td>
<td>24</td>
<td>7/8</td>
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<tr>
<td>10</td>
<td>26</td>
<td>7/8</td>
</tr>
<tr>
<td>12</td>
<td>30</td>
<td>7/8</td>
</tr>
</tbody>
</table>

Vertical, all sizes every floor level

L. Install laboratory gas piping hangers with the following maximum spacing.

1. 1/2" Pipe Size: 6' O.C.
2. 3/4" Pipe Size: 7' O.C., 1" pipe size: 8'
3. 1-1/4" or Larger Pipe Size: 9' O.C.
4. 1-1/2" and larger: 10'
5. Vertical Piping: Every floor level.

M. Support horizontal cast iron pipe as follows:
1. Hub & Spigot: All sizes.
   a. 10 ft. max spacing: min of one (1) hanger per pipe section close to joint on the barrel. Also at change of direction and branch connections.
   b. Support vertical cast iron pipe at each story height and at its base. Secure vertical hub and spigot pipe immediately below the hub.
   c. Use hanger rods same size as for steel pipe.

2. No-Hub: All sizes
   a. With Clamp-All and Anaheim Series 4000 stainless steel couplings and MG cast iron couplings: one hanger to each joint.
   b. With all other stainless steel band type couplings: one hanger to each side of joint.
   c. Support all horizontal cast iron pipe within 18 inches of each joint and with 5 feet maximum spacing between hangers, except that pipe exceeding 5 feet in length shall be supported at intervals no greater than 10 feet.
   d. Use hanger rods same size as for steel pipe.
   e. Support vertical cast iron pipe at each story height and at its base. Support vertical no-hub pipe so that the weight is carried from the pipe to the support and not from the joint to the support.

N. Place a hanger within one foot of each horizontal elbow.

O. Use hangers which are vertically adjustable 1-1/2 inch minimum after piping is erected.

P. Support vertical steel and copper piping at every story height but at not more than 15 foot intervals for steel and 10 feet for copper.

Q. Where several pipes can be installed in parallel and at same elevation, provide trapeze hangers.

R. Where practical, support riser piping independently of connected horizontal piping.

S. Apply steam supply and condensate return pipe supports per 23 22 13 Steam Piping.

T. Each pipe drop to equipment shall be adequately supported. All supporting lugs or guides shall be securely anchored to the building structure.

U. Securely anchor and support plumbing domestic water piping in chases or walls. Use factory manufactured clamps and brackets connected to fixtures, waste/vent piping or brackets connected to studs. Wires or straps will not be permitted.

1. When copper supplies are connected to flush valves, support the tubing by the studs or by a fixture, not by clamping to waste/vent piping.

2. Prevent copper tubes from making contact with steel brackets using fire retardant polyethylene inserts or other dielectric insulating material. Duct tape shall not be used.

V. Install anchors and fasteners in accordance with manufacturer's recommendations and the following:
1. In the event a self-drilling expansion shield or machine bolt expansion shield is considered to have been installed improperly, the Contractor shall make an acceptable replacement or demonstrate the stability of the anchor by performing an on-site test under which the anchor will be subjected to a load equal to twice the actual load.

2. Powder-driven fasteners may be used only where they will be concealed after the construction is complete. Where an occasional fastener appears to be improperly installed, additional fastener(s) shall be driven nearby (not closer than 6 inches) in undisturbed concrete. Where it is considered that many fasteners are improperly installed, the Contractor shall test load any 50 successively driven fasteners. If 10 percent or more of these fasteners fail, the Contractor shall utilize other fastening means as approved and at no additional cost to the Owner.

3. Hangers for piping and ducts shall be attached to cellular steel floor decks with steel plates and bolted rod conforming to the steel deck manufacturer's requirements. Where the individual hanger load exceeds the capacity of a single floor deck attachment, steel angles, beams or channels shall be provided to span the number of floor deck attachments required.

4. Welding may be used for securing hangers to steel structural members. Welded attachments shall be designed so that the fiber stress at any point of the weld or attachment will not exceed the fiber stress in the hanger rod.

W. Place a hanger within 6” of both sides of a control valve.

X. Within walls, support vertical pipe every 6 feet where pipe supplies a fixture.

Y. Pipes on roofs shall be supported by roller supports of adjustable height. Wood blocks and straps are not acceptable for lengths greater than six feet.

3.5 INSTALLATION OF ANCHORS:

A. Install anchors at proper locations to prevent stresses from exceeding those permitted by ANSI B31.9, and to prevent transfer of loading and stresses to connected equipment.

B. Fabricate and install anchor by welding steel shapes, plates and bars to piping and to structure. Comply with ANSI B31.9 and with AWS Standards D1.1.

C. Where expansion compensators are indicated, install anchors in accordance with expansion unit manufacturer's written instructions, to control movement to compensators.

D. Anchor Spacings: Where not otherwise indicated, install anchors at ends of principal pipe-runs, at intermediate points in pipe-runs between expansion loops and bends. Make provisions for preset of anchors as required to accommodate both expansion and contraction of piping. Provide shop drawing for review by Engineer.

3.6 SHEET METAL DUCT HANGERS AND SUPPORTS:

A. Provide in accordance with SMACNA HVAC duct construction standards.

B. Additional Hanger Requirements:

1. 2" to 24" from flexible connections of fans.
2. 2" to 24” from the outlets or flexible connections of VAV control units or mixing boxes.
3. 12” to 36” from the main duct to the first hanger of long branch ducts.
4. 2” to 12” from the ends of all branch ducts and linear diffuser plenums.
5. 2" to 24" from fire damper break-away joints.
6. Hangers at throat and heal of round or square elbows 48" or greater in width.

3.7 EQUIPMENT SUPPORTS:

A. Fabricate structural steel stands to suspend equipment from structure above or support equipment above floor.

B. Grouting: Place grout under supports for piping and equipment.

C. Concrete bases for the mechanical equipment indoors or outdoors will be provided by the General Contractor only if shown on the architectural or structural drawings. Otherwise, all bases shall be provided by this Contractor.

D. Housekeeping bases shall be 4 inches thick minimum, extended 4 inches beyond machinery bedplates.

E. This Contractor shall be responsible for the proper size and location of all bases and shall furnish all required anchor bolts and sleeves. If bases are provided by the General Contractor, furnish him with templates showing the bolt locations.

F. Equipment shall be secured to the bases with anchor bolts of ample size. Bolts shall have bottom plates and pipe sleeves and shall be securely imbedded in the concrete. All machinery shall be grouted under the entire bearing surface. After grout has set, all wedges, shims and jack bolts shall be removed and the space filled with non-shrinking grout. This Contractor shall provide lead washers at all equipment anchor bolts.

G. Construct equipment supports above floor of structural steel members or steel pipe and fittings. Brace and fasten with flanges bolted to structure.

H. Provide rigid anchors for ducts and pipes immediately after vibration connections to equipment.

3.8 PREFABRICATED ROOFTOP EQUIPMENT SUPPORTS:

A. Equipment Bases:

1. Equipment base shall be solid top combination equipment base with integral duct curb and stepped cant to match roof insulation. Base shall pitch to match roof pitch and provide level unit installation.

2. Base shall be constructed of reinforced 18 gauge galvanized steel with all welded components, full mitered corners, factory installed 1-1/2 inches thick rigid fiberglass insulation, wood nailer, and galvanized steel counter-flashing. Base shall be shipped as one piece.

B. Equipment Rails:

1. Equipment rail shall be constructed of 18 gauge galvanized steel shell, base plate, and counterflashing with factory installed wood nailer, fully mitered end sections, stepped cant to match roof insulation. Rails shall pitch to match roof pitch and provide level installation.

C. All supports shall be installed in accordance with manufacturer's recommendations.
3.9 METAL FABRICATION:

A. Cut, drill, and fit miscellaneous metal fabrications for pipe anchors and equipment supports. Install and align fabricated anchors in indicated locations.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1 for procedures of manual shielded metal-arc welding, appearance and quality of welds made, methods used in correcting welding work, and the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.

2. Obtain fusion without undercut or overlap.

3. Remove welding flux immediately.

4. Finish welds at exposed connections so no roughness shows after finishing and contours at welded surfaces match adjacent contours.

3.10 ADJUSTING:

A. Hanger Adjustment: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Touch-Up Painting: Immediately after erection of anchors and supports, clean field welds and abraded areas of shop paint and paint exposed areas with same material as used for shop painting to comply with SSPC-PA-1 requirements for touch-up of field-painted surfaces.

1. Apply by brush or spray to provide a minimum dry film thickness of 2.0 mils.

C. For galvanized surfaces clean welds bolted connections and abraded areas and apply galvanizing repair paint to comply with ASTM A 780.

END OF SECTION 23 05 29
SECTION 23 05 48
VIBRATION CONTROL

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this section.

B. Extent of vibration control work required by this section is indicated on drawings and schedules, and/or specified in other Division 23 sections.
   1. This Section specifies the requirements for vibration control systems to be used in all phases of mechanical work.
   2. This Specification provides the necessary design for the avoidance of excessive vibration in the building due to the operation of machinery or equipment and/or due to interconnected piping, ductwork, conduit, or structures.
   3. Due to the nature of this facility the design criteria may exceed those of normal industrial construction. It is imperative that close attention be paid to all specifications and details for noise and vibration control.
   4. All mechanical equipment, piping and ductwork as noted or in the specification shall be mounted on vibration isolators to prevent the transmission of vibration and mechanically transmitted sound to the building structure. Vibration isolators shall be selected in accordance with the weight distribution so as to produce reasonably uniform deflections.
   5. Any variance or non-compliance with these specification requirements shall be corrected by the contractor in an approved manner.

C. The work in this section includes, but is not limited to the following:
   1. Vibration isolation for piping, ductwork and equipment.
   2. Equipment isolation bases.
   3. Flexible piping connections.
   4. All mechanical and electrical systems (installed by Division 22/23, e.g., Temperature Controls). Equipment buried underground is excluded but entry of services through the foundation wall is included. Equipment referred to below is typical. (Equipment not listed is still included in this specification).

<table>
<thead>
<tr>
<th>AC Units</th>
<th>Cooling Towers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Distrib.Boxes</td>
<td>Ductwork</td>
</tr>
<tr>
<td>Air Handling Units</td>
<td>Control Panels</td>
</tr>
<tr>
<td>Air Separators</td>
<td>Fans (All types)</td>
</tr>
<tr>
<td>Boilers</td>
<td>Heat Exchangers</td>
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<tr>
<td>Cabinet Heaters</td>
<td>Piping</td>
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<tr>
<td>Cable Trays</td>
<td>Pumps (All types)</td>
</tr>
<tr>
<td>Chillers</td>
<td>Rooftop Units</td>
</tr>
<tr>
<td>Compressors</td>
<td>Tanks (All types)</td>
</tr>
<tr>
<td>Comp. Room Units</td>
<td>Unit Heaters</td>
</tr>
<tr>
<td>Condensers</td>
<td>Conduit</td>
</tr>
<tr>
<td>Water Heaters</td>
<td>Var. Freq. Drives (including isolation transformers)</td>
</tr>
</tbody>
</table>
5. Fire protection systems are excluded from this section; see under separate fire protection sections.

D. Vibration control products furnished as integral part of factory-fabricated equipment shall comply with the requirements of this section.

E. For additional and supplemental requirements, refer to other Division 23 sections for equipment foundations; hangers; sealants; gaskets; requirements of electrical connections to equipment isolated on vibration control products; requirements of duct connections to air handling equipment isolated on vibration control products.

F. Definitions

1. Life Safety Systems:
   a. All systems involved with fire protection including sprinkler piping, service water supply piping, water tanks and fire dampers. See separate section(s) for fire protection requirements.
   b. All systems involved with and/or connected to emergency power supply including all generators, transfer switches, transformers and all flowpaths to fire protection and/or emergency lighting systems.
   c. All life support systems.
   d. Fresh air relief systems on emergency control sequence including air handlers, conduit, duct, dampers, etc.

2. Positive Attachment:
   a. A positive attachment is defined as a cast-in anchor, a drill-in wedge anchor, a double sided beam clamp loaded perpendicular to a beam, or a welded or bolted connection to structure. Single sided "C" type beam clamps for support rods of overhead piping, ductwork, fire protection, electrical conduit, bus duct, or cable trays, or any other equipment are not acceptable on this project as seismic anchor points.

3. Transverse Bracing:
   a. Restraint(s) applied to limit motion perpendicular to the center line of the pipe, duct or conduit.

4. Longitudinal Bracing:
   a. Restraint(s) applied to limit motion parallel to the centerline of the pipe, duct or conduit.

1.2 QUALITY ASSURANCE:

A. Testing agency qualifications: an independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (nrtl) as defined by osha in 29 cfr 1910.7, and that is acceptable to authorities having jurisdiction.

B. Welding: qualify procedures and personnel according to aws d1.1/d1.1m, "structural welding code - steel."
1.3 CONTRACTOR'S GENERAL RESPONSIBILITIES:

A. The Contractor shall bring to the Architect's attention prior to installation any conflicts which will result in unavoidable contact between the building structure and the isolated equipment, piping, etc., described herein, due to inadequate space, etc. Corrective work necessitated by conflicts after installation shall be at the expense of the responsible contractor.

B. The Contractor shall bring to the Architect's attention prior to installation any discrepancies between the requirements of this Specification and field conditions, changes required due to specific equipment selection, etc. Corrective work necessitated by discrepancies after installation shall be at the expense of the responsible contractor.

1.4 DESIGN CRITERIA:

A. Equipment, ductwork, piping and conduit shall not be installed which makes rigid contact with the structure or rigidly-connected building components unless it is allowed by this specification.

B. Pipe Anchors and Supports: Piping supports and anchors shall not interfere with free operation of vibration isolation systems.

C. Systems, equipment, or parts which generate uncharacteristically high levels of noise or vibration while in operation, shall be (1) adjusted, repaired, or replaced as appropriate to obtain acceptable levels of vibration or noise, or (2) be supported on, or fitted with, suppression or absorption devices, or other means, which effectively prevent the transmission of vibration or noise beyond the offending item.

D. Systems, equipment, or parts which generate uncharacteristically high levels of noise or vibration while in operation, shall be (1) adjusted, repaired, or replaced as appropriate to obtain acceptable levels of vibration or noise, or (2) be supported on, or fitted with, suppression or absorption devices, or other means, which effectively prevent the transmission of vibration or noise beyond the offending item.

E. Resilient Wall, Ceiling, and Floor Penetrations: Provide resilient wall and ceiling penetrations for all isolated piping, conduit, ductwork, etc. Refer to resilient penetration details on the Drawings.

F. Pipe and duct flow velocities: The following guidelines for flow velocity shall be followed, unless superseded by the more stringent requirements of other specifications.

1. Maximum liquid and gas flow velocities anywhere shall not exceed 3 m/s and 12 m/s, respectively.

G. Structural Isolation Break: A structural isolation break (SIB) is defined as a continuous break in rigid structural and mechanical elements over the specified region of the structure, resulting in a functional separation between vibration generating and sensitive areas.

1. The SIB is characterized by a complete structural separation spanned only by the following:
   a. Architectural elements, piping, and ductwork containing high compliance expansion joints as specified herein; or
   b. Vibration isolated major piping, ducting, and conduit as specified herein; or
   c. Piping, ducting, and conduit which is small enough not to require isolation, as specified herein.

2. Suspended acoustical ceilings do not require treatment at SIBs.
3. Structural isolation breaks shall be provided at specified locations to reduce structural coupling between vibration sensitive areas and areas containing vibration producing equipment.

4. Individual runs of piping, ducting, and conduit which are smaller than the sizes specified as requiring treatment at SIBs are not considered a rigid connection.

5. High compliance expansion joints or loose flashing shall be used to close SIBs at above grade locations where closure is desired. Minimum 0.5 inch thick bituminous felt shall be used to close SIBs at slab-on-grade locations.

6. Architectural elements which cross any SIB shall be supplied with high compliance joints at the SIB as shown in drawings.

7. Conduit 12 inches or greater in nominal diameter and bus ducts which cross a SIB shall be supported on 1 inch deflection Type HS hangers for 25 feet on one side of the SIB or shall be provided with flexible conduit connections with a minimum 90 degree bend at the SIB. Flexible conduit connections shall be loose and highly compliant.

8. Piping Isolation:
   a. Piping isolation requirements at SIBs are based on metal pipe interior diameters. When evaluating isolation requirements for plastic pipe, determine effective pipe diameter by dividing actual diameter by two.
   b. Metal piping 4 inches or greater in diameter, and racks supporting pipes with equivalent or greater cross sectional areas, which cross the SIB shall be supported 1 inch deflection Type HS or Type FSN isolators (whichever is applicable to the mounting condition) for 25 feet on one side of the SIB. Pipes less than 1 inch in diameter are exempt from calculations for equivalent cross sectional area.

9. FRP ducting 300mm or greater in diameter which crosses the SIB shall be supported on 25mm deflection Type HS or Type FSN (whichever is applicable to the mounting condition) for 8m on one side of the SIB.

10. Fire protection piping and gravity metal drain lines 4 inches or greater diameter which cross the SIB shall be supported on 1 inch deflection Type HS or Type FSN isolators (whichever is applicable to the mounting condition) for 25 feet on one side of the SIB or be provided with Victaulic-style flexible connectors at the SIB.

11. Sheet metal ductwork greater than 24 inches in equivalent diameter which crosses the SIB shall be provided with flexible duct connections at the SIB.

1.5 SUBMITTALS:

A. Provide the following in addition to the standard requirements:

1. A general statement of materials and methods intended for use on this project within 45 days of subcontract execution or notice to proceed, whichever is later. Specific information shall be provided for all items described under the products section of this Specification. Complete specifications, descriptive drawings, catalog cuts, and descriptive literature, which shall include make, model, dimensions, weight and interface description with other work, shall be supplied. Complete performance data are required that shall indicate full compliance with specifications as outlined.

2. Complete detailed shop drawings showing the intended locations and construction features of all types of products specified. Shop drawings shall be submitted in a timely manner.

3. Catalog cuts and data sheets on specific vibration isolators shall be provided showing compliance with the specification.
4. An itemized list showing items to be isolated, the isolator type, model number, isolator loading and deflection, and reference to specific drawing showing frame construction where applicable.

5. Detailed selection data for each vibration isolator supporting equipment, including:
   a. The equipment identification mark.
   b. The isolator type.
   c. The actual load at each support point including all support equipment, piping, and thrust loads.
   d. The static deflection expected under the actual load.
   e. The specified minimum static deflection.
   f. The additional deflection to solid under load.
   g. The ratio of spring height under actual load to spring diameter.

6. Drawings showing equipment frame construction for each machine, including dimensions, structural member sizes, and support point locations.

7. Written approval of the frame design to be used shall be obtained from the equipment manufacturer.

8. Drawings showing methods for suspension, of support, and guides.

9. Drawings showing methods for isolation of piping, at penetrations of walls, slabs, and beams.

10. Product data to illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.
    a. Annotate to indicate application of each product submitted and compliance with requirements.
    b. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

B. Delegated-Design Submittal: For vibration isolation details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

   1. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, and wind forces required to select vibration isolators, and wind restraints, and for designing vibration isolation bases.
      a. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Division 23 Sections for equipment mounted outdoors.

   2. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes. Include certification that riser system has been examined for excessive stress and that none will exist.

1.6 CODE AND STANDARDS REQUIREMENTS:

A. Applicable Codes and Standards

2. All State and Local Codes.

1.7 MANUFACTURER'S RESPONSIBILITY:

A. Manufacturer of vibration isolation equipment shall have the following responsibilities:

1. Determine vibration isolation sizes and locations.
2. Provide vibration isolation as scheduled or specified.
3. Provide calculations and materials if required for restraint of unisolated equipment.
4. Provide installation instructions, drawings and trained field supervision to insure proper installation and performance.

1.8 RELATED WORK:

A. Housekeeping Pads

1. Housekeeping pad reinforcement and monolithic pad attachment to the structure details and design shall be prepared by the restraint vendor if not already indicated on the drawings.

2. Housekeeping pads shall be coordinated with restraint vendor and sized to provide a minimum edge distance of ten (10) bolt diameters all around the outermost anchor bolt to allow development of full drill-in wedge anchor ratings. If cast-in anchors are to be used, the housekeeping pads shall be sized to accommodate the ACI requirements for bolt coverage and embedment.

B. Supplementary Support Steel

1. Contractor shall supply supplementary support steel for all equipment, piping, ductwork, etc. including roof mounted equipment, as required or specified.

C. Attachments

1. Contractor shall supply restraint attachment plates cast into housekeeping pads, concrete inserts, double sided beam clamps, etc. in accordance with the requirements of the vibration vendor's calculations.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS:

A. Acceptable Manufacturers: Subject to compliance with requirements, All products shall be supplied by one of the following approved manufacturers or manufacturers that meet all of the requirements of this spec:

3. Vibration Mountings & Controls Group. (V.M.C.), Bloomingdale, NJ.

B. General:

1. Metal parts of vibration-isolation units shall be as follows: galvanizing shall meet ASTM salt spray test standards and federal test standard no. 14.
a. Housing: hot-dipped galvanized or fusion epoxy coated.
b. Hardware (washers, nuts, bolts, etc.): cadmium plated.

2. All isolators installed outdoors shall have base plates with bolt holes for fastening the isolators to the support members.

3. Isolator types are scheduled to establish minimum standards. At the subcontractor’s option, labor-saving accessories can be an integral part of isolators supplied to provide initial lift of equipment to operating height, hold piping at fixed elevation during installation and initial system filling operations, and similar installation advantages. Accessories shall not degrade the vibration isolation system.

4. Static deflection of isolators shall be as indicated at the end of this section. All static deflections stated are the minimum acceptable deflection for the mounts under actual load.

5. The use of nested springs or of multiple parallel springs within a single mount is not permitted.

6. The use of housed springs is not permitted.

C. Type FSN (Floor Spring and Neoprene):

1. Spring isolators shall be free-standing and laterally stable without any housing. Spring diameter shall be not less than 0.8 times the compressed height of the spring at the design load. Springs shall have a minimum additional travel to solid equal to 50 percent of the actual deflection. Springs shall be so designed that the ratio of horizontal stiffness to vertical stiffness is approximately 1. All mounts shall have leveling bolts.

2. The spring element in the isolator shall either be set in a neoprene cup and have a steel washer to distribute the load evenly over the neoprene, or each isolator shall be mounted on a Type NP isolator. If the NP isolator is used, a rectangular bearing plate of appropriate size to load the pad uniformly within the manufacturer’s range shall be provided. If the spring isolator is supplied with a neoprene friction pad, a stainless steel, aluminum, or galvanized steel plate shall be used between the friction pad and the NP isolator. The NP isolator, separator plate, and friction pad shall be permanently adhered to one another and to the bottom of the bearing plate.

3. If the isolator is to be fastened to the building structure and a Type NP isolator is used under the bearing plate, neoprene grommets shall be provided for each bolt hole in the base plate. Bolt holes shall be properly sized to allow for grommets. Hold down bolt assembly shall include washers to distribute load evenly to the grommet. Bolts and washers shall be galvanized.

4. Type FSN isolators shall be one of the following products, or approved equal, with the appropriate neoprene pad (if used) selected from Type NP:

   a. Mason Industries: Model SLF
   b. Kinetics Noise Control: Model FDS
   c. Vibration Mountings & Controls: Model AC

D. Type FSNTL (Floor Spring and Neoprene Travel Limited):

1. Spring isolators shall be free-standing and laterally stable without any housing. Spring diameter shall be not less than 0.8 times the compressed height of the spring at the design load. Springs shall have a minimum additional travel to solid equal to 50 percent of the actual deflection. Springs shall be so designed that the ratio of horizontal stiffness to vertical stiffness is approximately 1. All mounts shall have leveling bolts. All mounts shall have vertical travel limit stops to control extension when weight is removed. The travel limit stops shall be capable
of serving as blocking during erection of the equipment. A minimum clearance of 1/4 inch shall be maintained around restraining bolts and between the limit stops and the spring to avoid interference with the spring action.

2. The spring element in the isolator shall either be set in a neoprene cup and have a steel washer to distribute the load evenly over the neoprene, or each isolator shall be mounted on a Type NP isolator. If the NP isolator is used, a rectangular bearing plate of appropriate size to load the pad uniformly within the manufacturer’s range shall be provided. If the spring isolator is supplied with a neoprene friction pad, a stainless steel, aluminum, or galvanized steel plate shall be used between the friction pad and the NP isolator. The NP isolator, separator plate, and friction pad shall be permanently adhered to one another and to the bottom of the bearing plate.

3. If the isolator is to be fastened to the building structure and a Type NP isolator is used under the bearing plate, neoprene grommets shall be provided for each bolt hole in the base plate. Bolt holes shall be properly sized to allow for grommets. Hold down bolt assembly shall include washers to distribute load evenly to the grommet. Bolts and washers shall be galvanized.

4. Type FSNTL isolators shall be one of the following products, or approved equal, with the appropriate neoprene pad (if used) selected from Type NP:
   a. Mason Industries: Model SLR-A
   b. Kinetics Noise Control: Model FLS-1
   c. Vibration Mountings & Controls: Model AWR-1

E. Type FN (Floor Neoprene):
   1. Neoprene isolators shall be neoprene-in-shear type with steel reinforced top and base. All metal surfaces shall be covered with neoprene. The top and bottom surfaces shall be ribbed. Bolt holes shall be provided in the base and the top shall have a threaded fastener.
   2. The mounts shall include leveling bolts that may be rigidly connected to the equipment.
   3. Type FN isolators shall be one of the following products or approved equal:
      a. Mason Industries: Model ND
      b. Kinetics Noise Control: Model RD
      c. Vibration Mountings & Controls: Model R/RD

F. Type NP (Neoprene Pad)
   1. Neoprene pad isolators shall be one layer of 1/4-inch to 5/16-inch thick ribbed or waffled neoprene. Neoprene shall be 40 to 50 durometer. The pads shall be sized so that they will be loaded within the manufacturer's recommended range.
   2. Type NP isolators shall be one of the following products or approved equal:
      a. Mason Industries: Model W
      b. Kinetics Noise Control: Model NPS
      c. Vibration Mountings & Controls: Model Shear-Flex or Maxi-Flex

G. Type DNP (Double Neoprene Pad):
   1. Neoprene pad isolators shall be formed by two layers of 1/4-inch to 5/16-inch thick ribbed or waffled neoprene, separated by a stainless steel or aluminum plate. These layers shall be
permanently adhered together. Neoprene shall be 40 to 50 durometer. The pads shall be sized so that they will be loaded within the manufacturer’s recommended range.

2. Type DNP isolators shall be formed from one of the following products or approved equal:
   
a. Mason Industries: Model WSW
b. Kinetics Noise Control: Model NPS
c. Vibration Mountings & Controls: Multiple layers of Model Shear-Flex or Maxi-Flex

H. Type HS (Hanger Spring):
   
1. Vibration-isolation hangers shall consist of a free-standing laterally stable steel spring set into a neoprene cup, contained within a steel housing. The neoprene cup shall be manufactured with a grommet (or other element) to prevent the hanger rod from contacting the hanger housing. A steel washer shall be provided in the neoprene cup to evenly distribute load onto the neoprene.

2. The plate or washer at the top of the spring shall be welded to the spring. The hanger rod shall be securely fastened to this plate or washer using lock nuts. The hanger rod shall have a diameter not less than 5/8 inch. This design represents a modification to the product types given below. The modification is intended to limit the side-to-side motion of the hanger rod relative to the hanger casing.

3. Spring diameter and hanger housing hole sizes shall be large enough to permit the hanger rod to swing through a 30 degree arc before contacting the housing. Spring elements shall have minimum additional travel to solid equal to 50 percent of the actual deflection.

4. Upper hanger rod attachment shall be made through a neoprene rubber-in-shear element designed to avoid direct contact between the hanger rod and the isolator frame.

5. Springs shall be color coded for ease of identification and removable, for field connection.

6. Type HS isolators shall be one of the following products or approved equal:
   
a. Mason Industries: Model 30N (modified)
b. Kinetics Noise Control: Model SH (modified)
c. Vibration Mountings & Controls: Model RSH (modified)

I. Type HN (Hanger Neoprene):
   
1. Vibration-isolation hangers shall consist of a neoprene-in-shear or glass fiber element contained in a steel housing. A neoprene neck bushing (or other element) shall be provided where the hanger rod passes through the hanger housing to prevent the rod from contacting the hanger housing.

2. The diameter of the hole in the housing shall be sufficient to permit the hanger rod to swing through a 30 degree arc before contacting the hanger housing.

3. Type HN isolators shall be one of the following products or approved equal:
   
a. Mason Industries: Model HD
b. Kinetics Noise Control: Model RH

   2 Vibration Mountings & Controls: Model RH and RHD
2.2 VIBRATION ISOLATION EQUIPMENT BASES:

A. Acceptable Manufacturers: Subject to compliance with requirements, all products shall be supplied by one of the following approved manufacturers:

3. Vibration Mountings & Controls, Inc. (V.M.C.), Bloomingdale, NJ.

B. Type BSF (Base Steel Frame):

1. Steel base frames shall consist of structural steel sections sized, spaced, and connected to form a rigid base which will not twist, deform, or deflect in any manner which will negatively affect the operation of the supported equipment of the vibration-isolation mounts.

2. Frames shall be adequately sized to support basic equipment units and mounts plus any associated pipe elbow supports, duct elbow supports, electrical control elements, or other components closely related and requiring resilient support in order to prevent vibration transfer to the building structure. The depth of steel frame bases shall be at least 1/10 the longest dimension of the base with a minimum depth of 6 inches, but not more than 12 inches.

3. Frame bases shall include side mounting brackets for attachment to vibration isolators. Mounting brackets shall be located on the sides of the base that are parallel to the axis of rotation of the supported equipment.

4. Type BSF base shall be supplied by the isolator manufacturer and shall be one of the following products or approved equal:
   a. Mason Industries: Model WFSL
   b. Kinetics Noise Control: Model SFB or SRB
   c. Vibration Mountings & Controls: Model WFB

C. Type BIB (Base Inertia Base):

1. Concrete inertia bases shall be formed of stone-aggregate concrete (150 pounds per cubic ft.) and appropriate steel reinforcing cast between perimeter structural steel channels. Inertia bases shall be built to form a rigid base which will not twist, deform, or deflect, in any manner which would negatively affect the operation of the supported equipment or the vibration isolation mounts.

2. Inertia bases shall be adequately sized to support basic equipment units and motors plus any associated pipe elbow supports, duct elbow supports, electrical control elements, or other components closely related and requiring resilient support in order to prevent vibration transfer to the building structure. Inertia base depth shall be at least 1/12 the longest dimension of the inertia base but not less than 6 inches and not more than 12 inches.

3. The weight of the inertia base, as a minimum, shall be 1 to 2 times that of the total weight of the equipment (including the attached piping it is supporting and other applicable loads). In special applications such as reciprocating compressors, the inertia base weight requirement could be higher and shall be calculated on a case-by-case basis.

4. Inertia bases shall include side mounting brackets for attachment to vibration isolators. Mounting brackets shall be located on the sides of the base that are parallel to the axis of rotation of the supported equipment.
5. The steel frame and reinforcement shall be supplied by the vibration isolator manufacturer. Concrete shall be provided by the appropriate Subcontractor.

6. Inertia bases used to support vibration-isolated pumps shall be sized to provide support for pipe elbows and suction diffuser. Inertia bases used to support vaneaxial fans shall be long enough to support fan diffusion cones.

7. Frame and reinforcement for Type BIB bases shall be one of the following products or approved equal:
   a. Mason Industries: Model KSL
   b. Kinetics Noise Control: Model CIB-L or CIB-H

8. Vibration Mountings & Controls: Model WPF

2.3 SNUBBERS:

A. Snubbers to limit the vertical and horizontal motion of the isolated equipment under seismic load shall be fabricated from steel. A neoprene pad, 1/4-inch minimum thickness, shall be affixed at the point of contact. There shall be no contact between snubbers and the inertia base or equipment support frame during normal operation. Snubbers shall not interfere with the vibration isolation systems. Minimum of one snubber per side, four total, shall be required on each base. Snubbers must allow clear inspection of the non-contacting elements. Seismic snubbers shall meet seismic requirements defined in other sections of this specification.

B. Snubbers should be equal to the following or field-fabricated to a similar design.
   1. Mason Industries: Model Z-1225
   2. Kinetics Noise Control: Model HS-4

2.4 PIPE AND DUCT RESTRAINTS:

A. Seismic restraint cables shall be installed and adjusted to function without interfering with the isolation systems. Make precise adjustments to accomplish this with minimum cable slack after systems are put in operation.

B. Seismic sway brace system shall be equal to Model SCB Assembly manufactured by Mason Industries (M.I.), or field-fabricated to a similar design.

2.5 FLEXIBLE CONNECTORS:

A. Flexible Duct Connections: Flexible duct connections shall be supplied in accordance with industry standards. Material width shall be 150 percent of clear dimension in addition to width required for attachment. Flexible duct connections shall result in a loose and highly compliant connection. Provide 3-inch minimum clearance between equipment casing and ductwork.

B. Flexible Pipe Connections: Flexible pipe connectors shall be fabricated of Kevlar or nylon cord, fabric, and neoprene. Flexible pipe connections shall result in a flexible and highly compliant connection that can allow longitudinal, transverse, and angular movements and provide micro-vibration isolation. The flexible connections shall be selected and specially fitted, if necessary, to suit the system temperature, pressure, and fluid type. Rods or cables may be used to control extension of the connector if required by the manufacturer, but shall not inhibit movement necessary to provide sufficient vibration isolation. Flexible pipe connections shall be one of the following products or approved equal:
   1. Mason Industries: Model SFDEJ
2. Metraflex: Double Sphere (Type DS):

3. Vibration Mountings & Controls: Model VMT

C. Flexible Conduit Connections: Flexible conduit shall be formed of one continuous length of electro-galvanized spiral-wound steel strip. Liquid-tight flexible conduit shall be formed of one continuous length of electro-galvanized spiral-wound steel strip, with neoprene gasket.

2.6 THRUST RESTRAINTS:

A. Thrust restraints shall consist of pre-compressed steel spring, neoprene cup, threaded rod, and angle brackets designed to resist the effects of fan thrust and prevent the collapse or over extension of flexible duct couplings and attendant short circuiting of the fan vibration isolation system.

B. Minimum operating deflection of steel spring shall not be less than 1/2 the deflection of the equipment support isolator.

C. Thrust Restraints shall be one of the following products or approved equal: Mason Industries, Inc. (M.I): Model WBI and Model WBD.

2.7 RESILIENT PENETRATION SLEEVE/SEAL:

A. Provide resilient wall and ceiling penetrations for all piping, conduit, ductwork, etc., supported on vibration isolators. Refer to resilient penetration details on Drawings.

B. Resilient penetration sleeve/seals shall be field fabricated from a pipe or sheet metal section that is at least 1 inch larger in each dimension than the penetrating element and is used to provide a sleeve through the construction penetrated. The sleeve shall extend 1 inch beyond the penetrated construction on each side. The annular space between the sleeve and the penetrating element shall be packed tightly with glass fiber or mineral wool to within 1/4 inch of the end of the sleeve. The remaining 1/4 inch space on each side shall be filled with acoustical sealant to form an airtight seal. The penetrating element shall be able to pass through the sleeve without contacting the sleeve. Alternatively, prefabricated sleeves accomplishing the same result are acceptable. Coordinate with penetration details shown on the Drawings.

2.8 RESILIENT LATERAL GUIDES:

A. These units shall incorporate neoprene isolation elements which are specifically designed for providing resilient lateral bracing of vertically rising ducts or pipes.

B. Resilient lateral guides shall be one of the following products or approved equal:

1. Mason Industries: Model ADA

C. Vibration Mountings & Controls: Model MDPA

2.9 FACTORY FINISHES:

A. Finish: Manufacturer's standard prime-coat finish ready for field painting.

B. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.

1. Powder coating on springs and housings.
2. All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
3. Baked enamel or powder coat for metal components on isolators for interior use.
4. Color-code or otherwise mark vibration isolation and seismic and wind-control devices to indicate capacity range.

PART 3 - EXECUTION

3.1 GENERAL:

A. The Contractor shall obtain inspection from the Architect of any installation to be covered or enclosed prior to such closure.

B. The Contractor shall obtain written and/or oral instructions from the vibration isolation control device manufacturer as to the proper installation and adjustment of such devices.

C. The Contractor shall correct, at no additional cost, all installations which are deemed defective in workmanship or materials by the Architect.

D. The Contractor shall be responsible for proper operation of all systems, sub-systems, and services provided under this Section. The Contractor shall coordinate startup procedures, calibration, and system check-out with all sub-contractors involved. Any system operational problems shall be diagnosed. All correctional procedures shall be initiated by the various contractors as required to bring the system into compliance with the design, and the problem shall then be rechecked to verify that the system operates normally. Any remaining difficulties shall be brought to the attention of the Architect.

3.2 EXAMINATION:

A. Examine areas and equipment to receive vibration isolation and wind control devices for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 VIBRATION-CONTROL DEVICE INSTALLATION:

A. The installation or use of vibration isolators must not cause any change of position of equipment, conduit, piping or ducting, which would result in stresses in connections or misalignment of shafts or bearings. In order to meet this objective, equipment and attached systems shall be maintained in a rigid position during installation. The load shall not be transferred to the isolator until the installation is complete and under full operating conditions.

B. All plumbing, piping, and ducting at mechanical equipment connections is to be fully supported by specified hangers. Plumbing, piping, or ducting loads shall not be supported on mechanical equipment and its vibration mounts.

C. Comply with requirements in Division 07 Section "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.

D. Equipment Isolator Installation:

1. Space saver brackets shall be used for equipment supported on Type FSN vibration isolators.

2. The minimum operating clearance between the underside of the frame or inertia base and the pad or floor shall be 25 mm.
3. The frame shall be placed in position and supported temporarily by shims prior to the installation of the machine or isolators.

4. After the entire system installation is completed and under full operational load, the isolators shall be adjusted so that the load is transferred from the shims to the isolators. When all isolators are properly adjusted, the shims will be barely free and shall be removed.

E. Isolator Hangers

1. The isolators shall be installed with the isolator hanger box as close as possible to the structure.

2. The isolators shall be suspended from the stiffest element of the structure above. In framed construction, such elements consist of beams and girders.

3. Orientation of isolator assembly including support and load rods shall be within five degrees of vertical.

F. Thrust Restraints

1. Thrust restraints shall be provided in accordance with manufacturers recommendations for all horizontal discharge vibration isolated fans and air handlers where the air thrust exceeds 10 percent of the vibration isolated equipment weight.

2. Thrust is calculated in accordance with the following formula:

\[
\text{THRUST (LB)} = \text{TOTAL PRESSURE (INCHES W.C.)} \times 5.3 \times \text{AREA (SQ. FT.)}
\]

3. Thrust restraints shall be oriented parallel to the direction of thrust and located symmetrically about the center of thrust. Ducting at thrust restraints shall be designed to withstand thrust loading or an auxiliary structure shall be provided for thrust restraint mounting.

4. Thrust restraints shall not interfere with or restrict free operation of vibration isolation systems.

G. Equipment Restraints:

1. Indicate type and quantity of snubbers described in first subparagraph below on Drawings or in the HVAC Vibration-Control Schedule.

2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).

H. Install cables so they do not bend across edges of adjacent equipment or building structure.

I. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

J. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

K. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

L. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling.
Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid pre-stressed tendons, electrical and telecommunications conduit, and gas lines.

2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.

3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.

4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.

5. Set anchors to manufacturer's recommended torque, using a torque wrench.

6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4 EQUIPMENT ISOLATION:

A. Install isolators for fans, chillers, compressors, pumps and other such equipment as detailed in the Vibration Isolation Schedule or as otherwise required. Unless otherwise specified in the Vibration Isolation Schedule or reviewed in advance by the Architect, no equipment of more than 2 KW shall be attached to the structure without suitable vibration isolation. Where piping, ducting, or conduit connects to such equipment, provide flexible connectors as specified in Specifications or shown on the Drawings.

B. Mechanical equipment manufacturer shall approve complete vibration isolation system for all isolated equipment.

3.5 PIPING ISOLATION:

A. Pipe support isolation shall comply with the following general guidelines:

1. Spring isolators shall be selected for a static deflection, under load, of not less than 25 mm. Type FSN or HS isolators (whichever is applicable to the mounting condition) shall be used.

2. Where lateral support of pipe risers is required within the specified limits of isolation, this shall be accomplished by use of Type FSN, Type HS or resilient lateral supports with the specified minimum static deflection.

3. Pipes that penetrate the building structure within the specified limits of isolation shall be isolated from the structure by use of resilient penetration sleeve/seals.

4. Drain piping connected to vibration-isolated equipment shall not contact the building structure or other non-isolated system unless it is resiliently mounted as described above.

5. Piping connected to vibration-isolated equipment shall be installed so that it does not strain or force out of alignment pipe flexes or vibration isolators supporting either the equipment or the piping.

6. Where pipes are racked together, the most stringent isolation requirement, as defined in this specification shall take precedence.
7. Limits of Isolation: Piping, 50 mm in diameter or greater, which is connected to vibration isolated equipment shall be isolated from the building structure using resilient (or spring) supports, resilient pipe guides, and resilient penetration sleeves (as applicable) for a distance of 8 m or 50 pipe diameters, whichever is greater.

8. Passive Mechanical Equipment: Passive mechanical equipment refers to equipment without motors such as cooling coils, plate and frame heat exchangers, etc. For passive mechanical equipment connected to vibration-isolated mechanical equipment by piping of length less than 8 m or 50 pipe diameters, whichever is greater, with a diameter equal to or greater than 50 mm:
   a. Provide vibration isolation flexible pipe connections at passive equipment.
   b. Support pipe connections between mechanical and passive equipment on hanger with the same type and deflection as the mechanical equipment support.

9. Gas, gravity drain, and fire protection piping are exempt from vibration isolation requirements.

B. Area - Specific Guidelines: Pipe support isolation shall follow the guidelines established for each area. These guidelines take into account each area's proximity to the process area and the structural configuration to allow for ease of installation and, at the same time, minimize the vibration transmitted to the process area.

3.6 SHEET METAL AND FRP DUCT ISOLATION:

A. Ductwork isolation requirements are based on duct equivalent diameters. For rectangular ductwork, the equivalent diameter is the diameter of duct having the same cross-sectional area.

B. The following general guidelines shall be followed:
   1. Spring isolators shall be selected for a static deflection, under load, of not less than 25 mm. Type FSN or HS isolators (whichever is applicable to the mounting condition) shall be used.
   2. Resilient lateral guides shall be used whenever lateral support of vertical duct runs is required within the limits for isolation specified below.
   3. Ductwork that penetrates the building structure within the limits of isolation specified below shall be isolated from the structure by use of resilient penetration sleeves/seals.
   4. Intake ducts and discharge ducts from all fans or fan units (isolated or not) greater than 7.5 KW shall be isolated from the building structure using spring supports for a distance of 8 m or 10 duct diameters, whichever is greater. Exhaust stacks and ducting connected to recirculation air handlers and penthouse makeup air handlers are exempt from this requirement.

C. Area - Specific Guidelines: Ductwork support isolation shall follow the guidelines established for each area. These guidelines take into account each area's proximity to the process area and the structural configuration to allow for ease of installation and, at the same time, minimize the vibration transmitted to the process area.

3.7 ELECTRICAL ISOLATION:

A. Electrical service connections to all vibration isolated mechanical equipment shall be made with flexible conduit. Conduit shall provide a minimum 90 degree turn and result in a loose and compliant connection.

3.8 EQUIPMENT BALANCE REQUIREMENTS:
A. All rotating equipment shall operate at speeds less than 80 percent of their true critical speed. Unless otherwise required, equipment shall be balanced according to the recommendations given in the following sections.

B. Equipment components such as motors, pump rotors, fan wheels, etc. shall be factory balanced, both statically and dynamically, to meet the field balance requirements described below.

C. Balance Criteria: Pumps, compressors, fans and other rotating equipment shall be field tested in accordance with ANSI Standard S2.41 (current edition) or International Standard ISO 10816-1 and 10816-3 (current edition) by an independent company after installation and under actual operating conditions. Vertical and horizontal vibration of rotating equipment shall not be greater than 1.8 mm/sec RMS (2.5 mm/sec 0-peak) velocity. The vibration shall be measured on the equipment bearing caps when the equipment is mounted on its vibration isolation mounts. A balance report shall be provided for each item of equipment.

D. Balance shall be achieved with the fans operating at rated airflow against the rated static pressure. Measurements shall be taken on the fan bearing caps in three orthogonal directions: parallel to the shaft and perpendicular to the shaft in two orthogonal planes. For systems with continuously adjustable blades and for systems that use variable frequency drives, the balance must be achieved at selected (not less than three) blade settings and shaft speeds within the normal design range of operation. Balance reports shall be provided for each item of equipment.

E. Factory Balance of Critical Fans: Special balance standards are required for fans of greater than 7.5 kW located within the process building, including the process support areas. For these fans, including recirculation air fans, makeup air fans, and exhaust (scrubbed, solvent, and general) fans, rotors shall be whirl-tested to 125 percent operating speed and balanced to ASHRAE standards or better. Fan/motor assemblies mounted on the specified isolation springs (within their cabinets if applicable) shall be dynamically balanced to within 0.635 mm/s RMS (0.889 mm/s 0-peak).

F. Field Balance of Critical Fans: The balance of Critical fans shall be checked following field installation. Adjustments shall be made as necessary to bring them within the specified limits. Balance reports shall be provided for each item of equipment.

G. Inertia Base or Skid-Mounted Equipment Balance: The weight of inertia bases or skids (and of any other components mounted on the same inertia base or skid) will reduce the vibration response when equipment is balanced. Therefore, the balance criteria shall be multiplied by the following factor for such equipment:

\[
\text{Factor} = \frac{W}{WT+W}
\]

Where

\[
WT = \text{Inertia weight (base + other components)}
\]

\[
W = \text{Weight of the subject equipment}
\]

3.9 FIELD QUALITY CONTROL:

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:
1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.

2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless post-connection testing has been approved), and with at least seven days' advance notice.


4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.

5. Test to 90 percent of rated proof load of device.


7. Measure isolator deflection.

8. Verify snubber minimum clearances.

9. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

3.10 ADJUSTING:

A. Adjust isolators after piping system is at operating weight.

B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

C. Adjust active height of spring isolators.

D. Adjust restraints to permit free movement of equipment within normal mode of operation.

PART 4 - SCHEDULES

4.1 EQUIPMENT ISOLATOR AND SEISMIC RESTRAINT SCHEDULE:

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END OF SECTION 23 05 48
SECTION 23 05 53
MECHANICAL IDENTIFICATION

PART 1 - GENERAL

1.1 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacturer of identification devices of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Codes and Standards:

1. ANSI Standards: Comply with ANSI A13.1 for lettering size, length of color field, colors, and viewing angles of identification devices.

2. ANSI Z53.1 “Safety color code for marking Physical Hazards” ASHRAE.

1.2 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data and installation instructions for each identification material and device required.

B. Schedules: Submit valve schedule for each piping system, typewritten and reproduced on 8-1/2" x 11" bond paper. Tabulate valve number, piping system, system abbreviation (as shown on tag), location of valve (room or space), size of valve, and variations for identification (if any). Only tag valves which are intended for emergency shut-off and similar special uses, such as valve to isolate individual system risers, individual floor branches or building system shut off valves. In addition to mounted copies, furnish extra copies for Maintenance Manuals as specified in Division 23.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Manufacturer: Subject to compliance with requirements, provide products by one of the following:

B. Mechanical Identification:

2. Seton Name Plate Corp.

2.2 MECHANICAL IDENTIFICATION MATERIALS:

A. General: Provide manufacturer's standard products of categories and types required for each application as referenced in other Division 23 sections. Where more than single type is specified for application, selection is Installer's option, but provide single selection for each product category.

2.3 PAINTED IDENTIFICATION MATERIALS:

A. Stencils: Standard fiberboard stencils, prepared for required applications with letter sizes generally complying with recommendations of ANSI A13.1 for piping or to match existing size in existing building, but not less than 1-1/4" high letters for ductwork and not less than 3/4” high letters for access door signs and similar operational instructions.
B. Stencil Paint: Standard exterior type stenciling enamel; black, except as otherwise indicated; either brushing grade or pressurized spray-can form and grade.

C. Identification Paint: Standard identification enamel of colors indicated or, if not otherwise indicated comply with ANSI A13.1 for colors or to match existing building standard identification.

2.4 PLASTIC PIPE MARKERS:

A. Snap-On Type: Provide manufacturer's standard pre-printed, semi-rigid snap-on, color-coded pipe markers, complying with ANSI A13.1.

B. Insulation: Furnish 1 inch thick molded fiberglass insulation with jacket for each plastic pipe marker to be installed on uninsulated pipes subjected to fluid temperatures of 125 degrees F. (52 degrees C.) or greater. Cut length to extend 2 inches beyond each end of plastic pipe marker.

C. Small Pipes: For external diameters less than 6 inches (including insulation if any), provide full-band pipe markers, with direction of flow arrows, extending 360 degrees around pipe at each location, fastened by one of the following methods:

1. Snap-on application of pre-tensioned semi-rigid plastic pipe marker.
   a. Setmark Type SNA

2. Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 3/4 inch wide; full circle at both ends of pipe marker, tape lapped 1-1/2 inch.

D. Large Pipes: For external diameters of 6 inches and larger (including insulation if any), provide Setmark Type STR, fastened by one of the following methods:

1. Steel spring or non-metallic fasteners.

2. Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 1-1/2 inches wide; full circle at both ends of pipe marker, tape lapped 3 inches.

3. Strapped-to-pipe (or insulation) application of semi-rigid type, with manufacturer's standard stainless steel bands.

E. Pressure Sensitive Markers: Brady Type 350 flexible vinyl film identification markers and tape, with legend, size and color per ANSI A-13.1.

F. Lettering: Comply with piping system nomenclature as specified, scheduled, shown, or to match existing building lettering nomenclature system and abbreviate only as necessary for each application length.

G. Arrows: Print each pipe marker with arrows indicating direction of flow, either integrally with piping system service lettering (to accommodate both directions), or as separate unit of plastic.

2.5 PLASTIC DUCT MARKERS:

A. General: Provide manufacturer's standard laminated plastic, duct markers.

B. For hazardous exhausts, use colors and designs recommended by ANSI A13.1.

C. Nomenclature: Include the following:
1. Direction of air flow.
2. Duct service (supply, return, exhaust, etc.)

2.6 PLASTIC TAPE:
   A. General: Provide manufacturer’s standard color-coded pressure-sensitive (self-adhesive) vinyl tape, not less than 3 mils thick.
   B. Width: Provide 1-1/2 inches wide tape markers on pipes with outside diameters (including insulation, if any) of less than 6 inches, 2-1/2 inches wide tape for larger pipes.
   C. Color: Comply with ANSI A13.1, except where another color selection is indicated.

2.7 UNDERGROUND-TYPE PLASTIC LINE MARKERS:
   A. General: Manufacturer’s standard permanent, bright-colored, continuous-printed plastic tape, intended for direct-burial service; not less than 6 inches wide x 4 mils thick. Provide tape with printing which most accurately indicates type of service of buried pipe.
   B. Provide multi-ply tape consisting of solid aluminum foil core between 2-layers of plastic tape.

2.8 ENGRAVED PLASTIC-LAMINATE SIGNS:
   A. General: Provide engraving stock melamine plastic laminate, complying with FS L-P-387, in the sizes and thicknesses indicated, engraved with engraver’s standard letter style of the sizes and wording indicated, black letters on light contrasting background color except as otherwise indicated, punched for mechanical fastening except where adhesive mounting is necessary because of substrate.
   B. Thickness: 1/8 inch, except as otherwise indicated.
   C. Fasteners: Self-tapping stainless steel screws, except contact-type permanent adhesive where screws cannot or should not penetrate the substrate.

2.9 PLASTICIZED TAGS:
   A. General: Manufacturer’s standard pre-printed or partially pre-printed accident-prevention tags, of plasticized card stock with matt finish suitable for writing, approximately 3-1/4 inch x 5-5/8 inch, with brass grommets and wire fasteners, and with appropriate pre-printed wording including large-size primary wording (as examples; DANGER, CAUTION, DO NOT OPERATE).

2.10 LETTERING AND GRAPHICS:
   A. General: Coordinate names, abbreviations and other designations used in mechanical identification work, with corresponding designations shown, specified, scheduled and approved by the Owner/Engineer. Provide numbers, lettering and wording as indicated and approved by the Owner/Engineer for proper identification and operation/maintenance of mechanical systems and equipment.
   B. Multiple Systems: Where multiple systems of same generic name are shown and specified, provide identification which indicates individual system number as designated on the drawings or schedule as well as service.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS:
A. Coordination: Where identification is to be applied to surfaces which require insulation, painting or other covering or finish including valve tags in finished mechanical spaces, install identification after completion of covering and painting. Install identification prior to installation of acoustical ceilings and similar removable concealment.

3.2 DUCTWORK IDENTIFICATION:

A. General: Identify air supply, return, exhaust, intake and relief ductwork and duct access doors with duct markers; or provide stenciled signs and arrows, showing ductwork service and direction of flow, in black or white (whichever provides most contrast with ductwork color). Existing building identification shall match the existing method which exists in the building.

B. Location: In each space where ductwork is exposed, or concealed only by removable ceiling system, locate signs near points where ductwork originates or continues into concealed enclosures (shaft, underground or similar concealment), and at 50 foot spacing along exposed runs.

C. Access Doors: Provide duct markers or stenciled signs on each access door in ductwork and housings, indicating purpose of access (to what equipment), other maintenance and operating instructions, and appropriate safety and procedural information.

D. Concealed Doors: Where access doors are concealed above acoustical ceilings or similar concealment, plasticized tags may be installed for identification in lieu of specified signs, at Installer's option.

3.3 PIPING SYSTEM IDENTIFICATION:

A. General: Install pipe markers of the following type on each system indicated to receive identification, and include arrows to show normal direction of flow. Existing building identification shall match the existing method which exists in the building.

B. Plastic pipe markers, with application system as indicated under "Materials" in this section. Install on pipe insulation segment where required for hot non-insulated pipes.

C. Locate pipe markers and color bands as follows wherever piping is exposed to view in occupied spaces, machine rooms, accessible maintenance spaces (shafts, tunnels, plenums) and exterior non-concealed locations.

D. Near each valve and control device.

E. Near each branch, excluding short take-offs for fixtures and terminal units; mark each pipe at branch, where there could be question of flow pattern.

F. Near locations where pipes pass through walls or floors/ceilings, or enter non-accessible enclosures.

G. At access doors, manholes and similar access points which permit view of concealed piping.

H. Near major equipment items and other points of origination and termination.

I. Spaced intermediately at maximum spacing of 25 feet along each piping run, except reduce spacing to 15' in congested areas of piping and equipment.

J. On piping above removable acoustical ceilings.

K. Legend on steam piping, condensate return, compressed air, gas and vacuum system shall include working pressure or vacuum.
3.4 UNDERGROUND PIPING IDENTIFICATION:

A. General: During back-filling/top-soiling of each exterior underground piping systems, install continuous underground-type plastic line marker, located directly over buried line at 6 inches to 8 inches below finished grade. Where multiple small lines are buried in common trench and do not exceed overall width of 16 inches, install single line marker. For tile fields and similar installations, mark only edge pipe lines of field.

3.5 VALVE IDENTIFICATION:

A. General: List each valve in valve schedule for each piping system. Provide a matrix indicating VAV box number.

1. Building services main shut-off valves.
2. Each individual system main shut-off valves.
3. Each individual system riser shut-off valves.
4. Each individual system floor shut-off valves.
5. Each individual system major branch shut-off valves.

B. Mount valve schedule frames and schedules in mechanical equipment rooms where directed by Architect/Owner/Engineer.

C. Where more than one major mechanical equipment room is shown for project, install mounted valve schedule in each major mechanical equipment room, and repeat only main valves which are to be operated in conjunction with operations of more than single mechanical equipment room.

3.6 MECHANICAL EQUIPMENT IDENTIFICATION:

A. UCB will provide Famis numbers and labels for the contractor to install. A spreadsheet will also be provided for the contractor to fill out.

B. General: Install minimum 2 inch x 4 inch engraved plastic laminate equipment marker on each individual items of mechanical equipment. Provide marker for the following general categories of equipment.

1. Main building systems control and operating valves, including safety devices and hazardous units such as gas outlets.
2. Fuel-burning units including boilers, furnaces, heaters, stills and absorption chillers.
3. Pumps, compressors, chillers, condensers and similar motor-driven units. Labels of Remote Equipment shall also indicate the space(s) being served and the location of their electrical breaker (panel ID, room no. and circuit).
   a. Identify pumps with service and zones served.
   b. Label refrigeration equipment with type and approximate quantity of refrigerant.
4. Heat exchangers, cooling towers, heat recovery units and similar equipment.
5. Fans and blowers.
6. Air terminal units.
7. Heaters, tanks and pressure vessels stencil as to service.
8. Water treatment systems and similar equipment.
9. Controls – Nameplate or Stencil:
   a. Magnetic starters and relays
   b. Manual overload switches-indicate “connected” or “controlled” equipment.
   c. Automatic controls, control panels, p.e switches, e/p switches, relays and starters.
d. Identify locations of control transformers on as-built drawings. Install labels on ceiling grid designating “CTRL XFMR”. Add tag at transformer indicating the device it serves.

C. Lettering Size: Minimum 1/4 inch high lettering for name of unit.

D. Text of Signs: In addition to the identified unit, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.

3.7 LIFT-OUT CEILINGS & ACCESS DOORS:

A. Provide Kroy type adhesive labels on ceiling tee or access door to identify concealed valves, air terminal units, fire/smoke and fire dampers, or similar concealed mechanical equipment which is directly above nameplate in ceiling space. Labels shall be black lettering on white background.

B. Use the following colors for specified labels:
   1. Fire protection devices, including dampers: 3/8” red letters on white background
   2. Air-handling terminal devices: 3/8” black letters on white background.
   3. Isolation, balancing and control valves: 3/8” black letters on white background.
   4. Isolation valves for plumbing: 3/8” blue letters on white background.

C. Label shall be installed oriented to read towards the ceiling tile that needs to be removed for access.

3.8 MOTORS CONTROLLED BY ENERGY MANAGEMENT SYSTEM:

A. The University shall furnish the following self-adhering signs which the Contractor shall install as indicated:

   CAUTION

   THIS EQUIPMENT IS UNDER COMPUTER CONTROL AND MAY CYCLE AT ANY TIME

   BEFORE WORKING ON IT, DISCONNECT THE ELECTRICAL POWER AND CONTACT THE
   UNIVERSITY SERVICE CENTER AT EXT. 2-5522.

3.9 ADJUSTING AND CLEANING:

A. Adjusting: Relocate any mechanical identification device which has become visually blocked by work of this division or other divisions.

B. Cleaning: Clean face of identification devices, and glass frames of valve charts.

END OF SECTION 23 05 53
1. DESCRIPTION OF WORK:

A. This section covers testing and balancing of environmental systems described herein and specified under Division 23. The testing and balancing of all environmental systems shall be the responsibility of one Testing, Balancing and Adjusting firm.

1. Test, adjust and balance the following mechanical systems and the mechanical equipment associated with these systems:


   b. Air Side Systems and Equipment
      1) Supply/Return Air Systems
      2) General Exhaust/Supply Fans
      3) Air Handling Units
      4) General Exhaust Systems
      5) Cabinet/Unit Heaters
      6) Unit Ventilators, Furnaces, Packaged Air Conditioning Units
      7) Lab and Research Facility Systems Kitchen/Service Hood Exhaust Systems
      8) Heat Recovery Systems

   c. Hydronic Systems and Equipment
      1) Heating/Chilled water systems
      2) Condenser water systems
      3) Hydronic coils
      4) Radiators/Conectors
      5) Heat exchangers
      6) Hydronic Pumps
      7) Heating Water Boilers
      8) Heat Recovery Systems

   d. Plumbing
      1) General
      2) Sewage Ejector/Sump Pumps
      3) Circulating Pumps
      4) Water Heaters
      5) Pure Water Distribution Systems
      6) House Compressed Air
      7) Laboratory Compressed Air
      8) Laboratory Vacuum

   e. Steam Systems and Equipment
      1) General
      2) Steam coils
      3) Boilers
      4) Humidification systems and equipment
f. Refrigeration Systems and Equipment
   1) General
   2) Chillers
   3) Cooling Towers
   4) Evaporator coils

g. Gas Fired Systems and Equipment
   1) General

h. Electrical Components
   1) Electric resistance heating
   2) Manual and magnetic starters
   3) Variable frequency drives

i. Control Systems and Equipment
   1) General

j. Life Safety Systems and Equipment
   1) Fire/smoke dampers and detection systems
   2) Engine generator systems and equipment

1.2 QUALIFICATIONS OF CONTRACTOR:
   
   A. The General Contractor shall procure the services of an independent testing and balancing agency specializing in the testing, adjusting and balancing of environmental systems to perform the above mentioned work. An independent contractor is defined as an organization that is not engaged in engineering design or is not a division of a mechanical contractor entity, which installs mechanical systems.

   B. The actual fieldwork shall be performed by qualified technicians who are currently certified by the Testing, Adjusting and Balancing Bureau (TABB), the National Environmental Balancing Bureau (NEBB), or the Associated Air Balance Council (AABC) certification agencies. The work shall be executed under the direct supervision of a Registered Professional Engineer having an established professional office in the State of Colorado and having an experience record of not less than five (5) years in the mechanical contracting industry in testing, adjusting and balancing or air and hydronic mechanical systems for not less the two (2) years of that time.

   C. The Testing & Balancing Contractor shall have a minimum of three years experience in testing and balancing mechanical systems.

   D. The Test & Balance Contractor shall have previous experience in testing and balancing variable air volume laboratory fume hood systems in the last two years. Qualification submission must include a detailed resume describing past project experience in laboratory variable air volume systems, a list of projects, including peoples’ names, phone numbers and addresses of references.

1.3 APPROVAL OF CONTRACTOR:
   
   A. The following firms are approved contractors to complete the work.
1. Checkpoint Balance
2. Lawrence H. Finn & Assoc.
3. TAB Services, Inc.
4. JPG Engineering

B. The test and balance contractor shall do the work under the general contractor, not the mechanical contractor.

1.4 CODES AND STANDARDS:


1.5 PRELIMINARY SUBMITTALS:

A. Within ten (10) days of award of the contract the General Contractor shall submit the name of the Test and Balance Contractor who will be performing the work. The submittal shall include a complete list of all technicians who will be performing the field work and include a photocopy of their current certification by either NEBB, AABC, or TABB certification agencies. Only those technicians included in the submittal shall perform the work. Any personnel or staff used to perform the work without prior approval of the Engineer, who are not included in the submittal, shall be grounds for rejecting the test and balance report and the project in whole.

B. Meet all requirements of Section 23 05 00 as applicable.

C. Submit a list of all instrumentation to be used on an individual project and include calibration dates. Submit calibration curves. If more than one instrument of a similar type is used, a comparison of individual readings should be made. The variation between instrument readings should not exceed plus or minus 5%.

D. The contractor shall review the contract documents and submittals for location and type of balancing devices being installed by the sheet metal and mechanical contractors, and issue to the engineer and UCB indicating they are adequate or shall identify deficiencies needing attention.

E. Prior to the start of any test and balance work of the mechanical system, the Contractor shall submit six (6) copies of a Preliminary Systematic Procedure. This shall include all preliminary information requested in Part 3 of this Section.

1.6 FINAL REPORTS:

A. Refer to Division 1 for supplemental requirements.

B. The Testing and Balancing Contractor shall submit six (6) bound copies of the final testing and balancing report at least fifteen (15) calendar days prior to substantial completion, unless noted otherwise in Division 1. Report contents shall be per Part 3 of this Section.

C. Meet all requirements of Section 23 05 00 as applicable.

D. If more than two reports are made by the contractor, the Owner reserves the right to charge the contractor for subsequent reviews by their consultants. Such extra fees shall be deducted from payments by the Owner to the contractor.
1.7 SEQUENCING AND SCHEDULING:

A. Notify Contractor/Engineer/Architect in writing of conditions detrimental to the proper completion of the test and balance work. Provide the Contractor/Architect/Engineer with a copy of the notification.

B. Prepare a project schedule. Schedule shall indicate critical path of the balancing process and shall incorporate both requirements of other contractors necessary to meet test and balance commitments and process flow of test and balance work. Coordinate with general and mechanical contractors and insert critical steps into project master schedule.

PART 2 - PRODUCTS

2.1 BELTS, SHEEVES, IMPELLERS:

A. Refer to specific equipment sections and Section 23 05 00 for additional requirements.

B. The Testing & Balancing Contractor shall coordinate with the Mechanical Contractor to supply correctly sized drive belts and sheeves. Impellers shall be trimmed or replaced by the mechanical contractor and shall be correctly re-sized and coordinated by the Test and Balancing Contractor per the hydronic systems and equipment portion of this section.

C. The Test & Balance Contractor shall determine the fan belt and sheeve replacement necessary for final balance condition for specified air quantity when the VFD is operating in the by-pass mode for final field conditions, without placing the motor over its nameplate amp rating.

PART 3 - EXECUTION

3.1 PRELIMINARY PROCEDURES:

A. Testing and balancing shall not begin until the system has been completed and is in full working order and the following project conditions have been determined suitable for start of work.

1. Preliminary Testing & Balancing Contractor requirements shall be ascertained prior to the commencement of work through a review of the project plans and specifications. In addition, visual observations at the site during construction shall be made to determine the location of required balancing devices, that they are being installed properly, and in an accessible location for the need. Report in writing any deficiencies to the Contractor/Engineer/Architect immediately.

2. Before any air balance work is done, the system shall be checked for duct leakage (obtain pressure test results), assure filters are installed, verify filters are changed if they are dirty, check for correct fan rotation, equipment vibration, and check automatic dampers for proper operation. All volume control dampers and outlets shall be wide open at this time.

3. Before any Hydronic, domestic water or applicable system balancing work is done, the systems shall be checked for plugged strainers, proper pump rotation, proper control valve installation and operation, air locks, proper system static pressure to assure a full system, proper flow meter and check valve installation. All throttling devices and control valves shall be open at this time.

4. Verify systems do not exhibit excessive sound and/or vibration levels. Report in writing any deficiencies to the Contractor/Engineer/Architect immediately.
B. Testing and balancing shall not begin until a Preliminary Systematic Procedure has been completed. This procedure shall be developed from manufacturers’ data, shop drawings and construction documents and submitted before the start of installation of the mechanical system. This procedure shall be coordinated with the Mechanical Contractor. Preparatory work includes the planning and scheduling of all TAB procedures, collecting necessary data, reviewing data, studying the systems to be balanced, recording the published data on the test report forms, and making preliminary field checks of the HVAC equipment and systems.

C. Submit the following data for the Preliminary Systematic Procedure, bound in a 3-ring binder:

1. Preliminary Testing and Balancing Schedule.
   a. Prepare a project schedule. Schedule shall indicate critical path of the balancing process and shall incorporate both requirements of other contractors necessary to meet test and balance commitments and process flow of test and balance work. Coordinate with GC and insert critical steps into project master schedule.

2. Procurement of Data.
   b. Manufacturer’s Performance Data for all equipment to be balanced: Data shall include air and Hydronic pressure differences, the direction of air and water flow, temperature differentials, Btu capacities, operating temperatures and pressures, and limit of safety temperatures and pressures.
   c. Fan and Pump Motor Nameplate Data.
   d. Motor Starters, Sizes, Locations and Thermal Overload Protection Ratings.
   e. Drives: Sheave data, pitch diameters, belt sizes and number, limits of adjustment, type of belt guards, etc.
   f. Effective areas (K factors) for all air terminal devices for the velocity-measuring instrument recommended. Also obtain air pattern adjustment and sound data.
   g. Manufacturer’s Data and Test Procedures: On all air handling devices, such as variable air volume boxes, constant volume regulators, static pressure dampers, etc.
   h. Manufacturer’s data for air pressure drop across louvers, filter banks; sound traps, remote coils and other devices in the air distribution system shall be obtained. Note whether louvers are provided with screening, whether filter pressure drop data is for clean, partially dirty, or dirty filters.
   i. Temperature Control Diagrams: Obtain necessary data required for TAB work.
   j. Assemble manufacturer’s catalog data for all HVAC equipment, including pumps, air moving and air terminal devices. This requirement is in addition to shop drawings and submitted data where possible. Only include performance data, which pertains to the T&B. Construction technical data is not required.
   k. All data shall be compared to the information on the construction documents. Discrepancies shall be identified for review by the Engineer. All data shall be recorded in the design columns of NEBB report forms.

a. Submit reduced drawings of each HVAC duct system. The test and balance contractor can obtain drawing files from Cator, Ruma, & Associates for development of these drawings.

b. Submit similar drawings for extensive piping systems.

c. In large buildings or where there is more than one system, submit a separate layout for each floor or for each system. Identify test locations, outlets, etc. on these drawings.

d. All test locations shall be numbered, which include dampers, regulating devices, terminal units, supply outlets, return and exhaust inlets.

e. Indicate the sizes, velocities and flow (CFM or gpm) for main and branch circuits or ducts. Include the air intakes and exhaust air and relief air louvers.

f. For rapid identification and for reporting purposes, all outlets shall be numbered. The same applies to fan coil and/or heating/cooling units in Hydronic systems.

g. Clearly indicate thermostat locations and other special conditions needed by the TAB team in the field.


a. Report forms shall be standard NEBB forms. Generate custom forms that contain the information in this Section when a standard NEBB form does not exist for a piece of equipment. All design column spaces shall be fully filled out for this submittal. When additional information required by this Section, it shall be written in on the NEBB form.

b. If terminal airflows are to be determined by velocity readings, calculate and submit the terminal velocities using the manufacturer’s K factors.

c. Submit where Pitot traverses of duct mains and branches are to be made. Determine the number of readings, calculate velocities and set up the duct Pitot traverse test reports.

3.2 GENERAL SYSTEM AND EQUIPMENT PROCEDURES:

A. Balance all air and water flows at terminals within +10% to -5% of design flow quantities. Notify Contractor/Engineer/Architect in writing of conditions detrimental to the proper completion of the test and balance work. Provide the Contractor/Architect/Engineer with a copy of the notification.

B. Pressure relationships indicated on drawings shall take priority over air quantities.

C. Mark equipment settings with paint, including damper control positions, balancing cocks, circuit setters, valve indicators, fan speed control settings and similar controls and devices, to show final settings at completion of test-adjust-balance work.

D. Patch holes in insulation, ductwork and housings, which have been cut or drilled for test purposes, in a manner recommend by the original installer.

E. Measure, adjust and report equipment running motor amps and power factor, KW, rated motor amperage, listed motor power factor, voltage, and all nameplate data. Perform these measurements for all equipment operational modes.

F. Check and adjust equipment belt tensioning.
G. Check keyway and setscrew tightness. Report any loose screws and notify Mechanical Contractor prior to equipment balancing.

H. Record and include in report all equipment nameplate data.

I. Verify that all equipment safety and operating controls are in place, tested, adjusted and set prior to balancing.

J. Verify that manufacturer start-up has occurred per specification prior to balancing.

K. Replace all adjustable sheaves on multiple belt drives with fixed-speed sheaves.

3.3 AIR SIDE SYSTEMS AND EQUIPMENT PROCEDURES:

A. In addition to the procedures identified under each specific heading below, provide general data required by 3.2 above.

B. Filters shall be restricted to increase pressure drop to 50% of span between initial pressure drop and final recommended pressure drop for setting final airflows for fans. Check fan motor amps with clean filters and simulated loaded filters, and report for each piece of equipment. Equipment shall be supplied with clean filters upon completion of balance. Balance and report air quantities.

C. Supply/Return Air Systems:

1. Balance and report supply and return diffuser/grille quantities. Air diffusion patterns shall be set as noted on drawings and to minimize objectionable drafts and noise.

2. Provide full pitot traverses in duct mains downstream of supply fans, upstream of return fans, and in each zone duct downstream of a multizone unit. For VAV systems perform these at the system diversity condition (if any). Balance and report air quantities.

3. Provide full pitot traverses at each air terminal or duct coil. For VAV systems, perform these at zone maximum air condition. Balance and report air quantities.

4. Report design air device inlet or outlet size, actual inlet or outlet size, design and actual velocity through the orifice, for each terminal in the system.

5. Balance and report the above measurements in all system operational/modes.
   a. Minimum outside air and 100% outside air economizer mode.
   b. VAV maximum zone air condition and system diversity condition.
   c. Unoccupied mode.
   d. Two-speed fan, both speeds.
   e. VFD bypass mode and full system demand.
   f. General Exhaust/Supply Fans:

D. Adjust CFM to system requirements. For belt drive include sheave and belt exchange to deliver airflow within limits of installed motor horsepower and mechanical stress limits of the fan. Determine the limiting fan tip speed before increasing RPM. Final fan speed setting shall allow for filter loading (as
applicable) and shall establish proper duct pressures for operation of zone CFM regulators. For direct drive with speed taps: Set fan speed on tap which most closely approaches design CFM by adjusting the speed control After adjustment, check fans ability to re-start after powering down. Increase setting if required for proper starting.

1. Measure and report static pressures upstream and downstream of all fans.

2. Measure and report fan RPM. Do not increase RPM by more than 10% without prior authorization from the engineer.

3. Report design fan inlet or outlet size, actual inlet or outlet size, design and actual velocity through the orifice.

E. Air Handling Units:

1. On outdoor units, verify that positively or negatively pressurized curbs are free of leaks. Report.

2. For units with integral outside air intake and relief dampers, measure, adjust, set and report outside air, return air and relief air quantities. Perform this as specified under supply air systems.

3. Balance and report supply and return fan CFM, upstream static pressure and downstream static pressure.

4. Measure and report static pressure upstream and downstream of all AHU components such as coils, filters (clean and simulated dirty), dampers, etc.

5. After system and fan balance is complete, perform pitot traverses on all coils in 100% heating and cooling modes.

6. Units with economizers shall have all measurements performed and reported at minimum outside air, 100% outside air, and a 50/50% mixed air condition.

7. Units with operation modes for smoke evacuation and/or pressurization shall have all measurements performed and reported for all modes.

8. Balance variable air volume AHU fans for system design diversity. Supply and return fan static pressures shall be optimized for VAV system terminal device pressure requirements. Report fan, motor and VFD information as previously indicated. Verify that an overload condition does not exist when all system VAV boxes are 100% open.

9. Balance all air handling unit coils and report per hydronic, gas fired, steam or refrigeration equipment portions of this section.

10. Report design fan inlet or outlet size, actual inlet or outlet size, design and actual velocity through the orifice.

11. Balance and report all temperatures of airside and hydronics during normal operating modes.

12. Measure, adjust, set, balance and report outside air, return air and exhaust/relief air quantities for all air handling systems.

Air quantities shall be determined by pitot traverse/direct airflow measuring procedures where ever possible, where duct/inlet conditions do not allow for accurate direct measurement of outside air the following method shall be used:
Outside Air CFM = Supply Fan Total CFM - Return Fan Total CFM

In addition to the direct measuring of airflow quantities, measure and record outside air, return air and mixed air temperatures, determine thermal/mass energy balance and provide calculations to verify measured airflow quantities. Adjusting and setting the outside air quantity as a percentage of damper position will not be acceptable.

13. Measure and record building static pressure adjacent to entries. Adjust system to maintain +.05” w.c. Note any discrepancies.

F. General Exhaust Systems:


2. Provide full pitot traverses at each individual exhaust riser and at each exhaust fan. Balance and report.

3. Report design air device inlet or outlet size, actual inlet or outlet size, design and actual velocity through the orifice, for each terminal in the system.

G. Cabinet/Unit Heaters:


2. Balance all coils per hydronic, gas fired or steam equipment portions of this section.

H. Unit Ventilators/Furnaces/Packaged Air Conditioning Units:

1. Report static pressure across all unit components.

2. Balance and report supply air, return air and outside air quantities.

3. Report mixed air temperature and balance coils per hydronic, steam, electric resistance, gas fired or refrigeration portions of this section.

I. Laboratory and Research Facility System Requirements:

1. General requirements:
   a. Balance all rooms to required pressure relationships as noted on the drawings. Document in the test and balance report that all pressure relationships have been set as specified.
   b. Performance testing of the Room Pressurization Control System and the fume Hood Exhaust System shall be performed after the entire mechanical system for the building is complete. All systems shall have been calibrated, tested and balanced before performance testing begins.
   c. Performance testing shall be done by the balancing contractor in the presence of the Owner, user groups, and a representative from the Department of Environmental Health and Safety.
   d. The performance testing must be successfully completed before the Owner will accept control of the building’s mechanical system.
2. Fume Hood Exhaust Systems:
   a. Measure and set flows for all fume hoods, flammable storage cabinets, etc.
   b. Perform full Pitot traverses upstream of exhaust fans and balance and report air quantities. Perform this in fully open and closed hood sash positions.

3. Fume Hood Exhaust System Performance Evaluation:
   a. The Balancing Contractor shall demonstrate that the exhaust system and pressure relationships are performing properly under the conditions listed below.
   b. Verify that the exhaust fans on the roof are operating properly. The discharge dampers should be performing as specified and the fans should be operating smoothly without surging or vibrating excessively.
   c. During each step in the testing procedure, note any rooms, which exhibit excessive noise.
   d. Testing Conditions:
      1) With all fume hood sashes closed:
         a) Check the relative pressure relationships with smoke in several rooms on each floor.
      2) With all fume hood sashes open:
         a) Check the face velocity of the hood closest to and farthest from each exhaust riser. Do this on every floor.
      3) Close all the fume hood sashes served by one exhaust riser and open all the ones served by the other riser.
         a) Check the hoods with open sashes as for a.1) above
      4) Repeat condition b. for the second riser.
      5) Move all the fume hood sashes to a half open position.
         a) Check the hoods as above.
      6) Final balance shall be based upon diversity provided by the Engineer. Note diversity on balance reports. The hood face velocities, relative pressure relationships and stable fan operation must be recorded for all five-test conditions. This applies to all hoods and all rooms in the wing being tested, even if the test procedure does not specifically state that particular hood or room be tested. Design conditions with the appropriate diversity shall be maintained.
      7) The face velocity of a hood shall be considered acceptable if it is within (+) 10 feet per minute of its designed face velocity. Standard procedures for testing face velocity as published by SEFA (Scientific Equipment & Furniture Association) 1-1992 Laboratory Fume Hoods Recommended Practices, shall be followed.
4. Room Pressurization Control System Performance Evaluation:

The Balancing Contractor shall demonstrate with smoke that the correct relative pressure relationship is being maintained in each area. Every room for which a relative pressure value was assigned on the mechanical plans shall be tested.

The testing shall be performed in each room under the following conditions:

1) Door closed
2) Door open
3) In labs with fume hoods or bio-safety cabinets:
   a) Hood sash complete open
   b) Hood sash closed
   c) Hood sash partially open
4) Thermostat set to its minimum set point
5) Thermostat set to its maximum set point
6) If the correct pressure relationships cannot be demonstrated for a particular room, the room shall be retested after the problem has been corrected.

J. Kitchen/Service Hood Exhaust Systems:

1. General Requirements:

a. Balance all rooms to required pressure relationships as noted on the drawings. Document in the test and balance report that all pressure relationships have been set as specified.

b. Performance testing of the Room Pressurization Control System and the Hood Exhaust System shall be performed after the entire mechanical system for the building is complete. All systems shall have been calibrated, tested and balanced before performance testing begins.

c. Set, measure and report flows for all hoods.

d. Perform full pitot tube traverses upstream of exhaust fans and balance and report air quantities.
   1) In welded high temperature systems provide air quantities upstream of exhaust fans by summing the flows at all hoods.

e. Measure and report hood capture velocity profiles.

2. Exhaust system performance evaluation.

a. Verify room pressure relationships with smoke tests and report. The testing shall be performed in each room under the following conditions:

   1) Door closed
   2) Door open
   3) Thermostat set to its minimum set point
   4) Thermostat set to its maximum set point
   5) If the correct pressure relationships cannot be demonstrated, the room shall be retested after the problem has been corrected.
b. Verify hood capture velocities are adequate with smoke tests and report.

c. Verify that the exhaust fans on the roof are operating properly. The fans shall be operating smoothly without surging or vibrating excessively.

3.4 HYDRONIC SYSTEMS AND EQUIPMENT:

A. Heating/chilled water systems:

1. Hydronic Systems with Meters: The system shall be balanced proportionally using the flow meters. On completion of the balance, the following information shall be recorded in the report: Flow meter size and brand, required flow rate and pressure drop, valve settings on meters with a readable scale, flow rate in both full coil flow and full bypass modes. Contractor shall verify the meters are installed per the manufacturer's recommendations and shall notify the Mechanical Contractor of any deficiencies before utilizing meter.

2. Hydronic Systems without Meters (thermal or terminal rated pressure drop balance): The system shall be balanced proportionally to the terminal ratings. On completion of the balance the following information shall be recorded in the report: Design entering and leaving water temperature/pressure, final balanced entering and leaving water temperature/pressure drop.

3. For 3-way valve terminals/heat exchangers, set bypass flow to equal coil flow.

4. For primary/secondary systems, set crossover/bridle to have constant flow at all conditions.

5. Sample chilled and heating water and report on freeze and burst temperatures of the glycol water solution. Report glycol percentage.

6. Perform similar operations for Hydronic heat reclaim systems.

B. Condenser Water Systems and Equipment:

1. Measure and record system static pressure with pumps off.

2. Where 3-way bypass is used to control condenser water temperature set the control valve pressure valve to equal tower pressure drop in full bypass mode.

3. Measure, set and record system gpm at all flow measurement stations.

C. Hydronic Coils:

1. Balance, measure and report inlet and outlet air temperatures for cooling and/or heating design air quantities.

2. Balance, measure and report coil water flow, inlet and outlet water pressure and temperature.

3. Evaporative cooling coils: Measure and report inlet and outlet wet bulb and dry bulb temperature. Measure and report inlet and outlet pressure.

4. Calculate and report face velocities across chilled water and evaporative cooling coils.

D. Radiators and Convectors:

1. Balance, measure and report GPM, inlet temperature and outlet temperature/pressure at full heating.
E. Heat Exchangers:

1. Balance, measure and report water flow for full heating.
2. Report inlet and outlet water pressures and temperatures for full heating.
3. For steam to water heat exchangers, see steam equipment portion of this Section for additional requirements.

F. Hydronic Pumps:

1. Adjust and balance pumps to provide design system flow rate, and design flow to most remote system location. Trim or replace impellers as necessary to achieve this. Do not induce false head to achieve balance results, without the prior approval of the Engineer. See Part 2 - “Products” of this section.
   a. Prior to trimming of impellers, notify the Architect/Contractor/Engineer in writing of performance of pumps with and without false head induced.
2. Report impeller size, flow rate, inlet and outlet water pressure and pump shut-off head. Provide pump curve and operating point in final report. Include compensations for temperature and percentage glycol.

G. Heating Water Boilers:

1. Verify that the boiler has been properly cleaned, flushed and the burner is operating properly prior to balancing.
2. Check and report on proper operation of boiler feed pumps.
3. Confirm automatic and manual air vents are working properly. Vent system as necessary.
4. Balance, measure and report boiler water flow rate, inlet and outlet temperature and pressure.
5. Confirm that temperature and pressure safety relief valves are located properly and in working order.
6. Verify proper operation of emergency power OFF switches.
7. Provide data for builder operating conditions and thermal efficiencies.

3.5 PLUMBING SYSTEMS AND EQUIPMENT:

A. General:

1. Check, adjust and set temperature control devices to 110°F domestic hot water temperature and as indicated on drawings.
2. Adjust pressure-reducing stations, report downstream system static pressure.
3. Verify proper location and operation of ASME pressure and temperature relief valves.
4. Measure and report residual pressure at full flow at most remote plumbing fixture; requiring highest operating pressure (usually flush valve water closets).
5. Verify that most remote fixture has hot water available semi-instantaneously with recirculation system operating. Report.

B. Sewage Ejector/Sump Pumps:
   1. Verify proper discharge of sewage ejector and sump pump systems. Verify that units are meeting system demands. Report.

C. Circulating Pumps:
   a. Measure and report inlet and outlet pressure and flow rate.
   b. Balance pumps per Hydronic portion of this Section.

D. Water Heaters:
   a. Measure, set and report inlet and outlet temperatures.
   b. Balance and report per steam, electric or gas portions of this Section.

E. Pure Water Distribution Systems:
   1. Verify and report flow at all stations.
   2. Verify and report operation of irradiation devices.
   3. Measure and report recirculation system flow rate.
   4. Remove, inspect and clean all system particulate filters and strainers.

F. House Compressed Air Systems and Equipment:
   1. Verify and Report air pressure at all system equipment quick connects and terminations.
   2. Remove, inspect and clean all system filters/strainers.
   3. Verify system can maintain overrating pressure for 8 hours with air compressor disconnected. Report any noticeable losses in system pressure.
   4. Measure, set and report storage tank air pressure.
   5. Verify that pressure relief valves are in place and operating correctly.

3.6 **STEAM SYSTEMS AND EQUIPMENT:**

A. General:
   1. Check steam traps for correct operation with a pyrometer.
   2. Check and report all steam pressures downstream of pressure reducing stations.
   3. Remove, inspect and clean all system strainers.
4. Record steam pressures upstream and downstream of all major equipment such as boilers, steam coils and heat exchangers.

B. Boilers:

1. Verify that the boiler has been properly cleaned, flushed and the burner is operating properly prior to balancing.
2. Check and report on proper operation of boiler feed pumps.
3. Verify boiler water level is proper and steady during operation.
4. Confirm that temperature and pressure safety relief valves are located properly in working order.
5. Verify proper operation of emergency power OFF switches.

C. Humidification Systems and Equipment:

1. Measure and report steady state relative humidity for spaces.
2. Measure and report humidifier outlet relative humidities.
3. Steam Dispersion Grids:
   a. Measure and report entering and leaving air temperature, and leaving relative humidity.
   b. See steam portion of the Section.

3.7 REFRIGERATION SYSTEMS AND EQUIPMENT:

A. General:

1. Chillers:
   a. Measure, balance and report inlet and outlet chilled water temperature and pressure, ambient temperature, water flow rate, evaporative and condenser fluid pressure drops and flows, oil pressure, refrigerant suction and discharge pressure, and temperature compressor/fan KW and compressor/fan amps.
   b. Verify proper operation of emergency power OFF switches and refrigerant sensors.
   c. Perform all measurements at all stages of cooling.
   d. Coordinate balance process with equipment manufacturer start-up representative.

B. Cooling Towers:

1. Measure and report tower entering and leaving air wet bulb temperature. Compare entering wet bulb against ambient wet bulb to verify recirculation is not taking place. Report.
2. Measure and report entering and leaving water temperatures. Report ambient wet bulb that corresponds with these measurements.
3. Measure, balance and report water flow rate.
C. Evaporator Coils:
   1. Measure and report temperature upstream and downstream of evaporator coils at all stages of cooling at all design air quantities. Calculate and report coil face velocities.

3.8 GAS FIRED SYSTEMS AND EQUIPMENT:

A. General:
   1. Record gas pressures downstream of each pressure-reducing valve. Verify that pressures match those on construction documents and report.
   2. Measure and report flue temperature at all stages of heating.
   3. Measure and report temperatures upstream and downstream of gas-fired coils at all stages of heating at all design air quantities.
   4. Observe and report operation of all radiant gas fired heaters, at all stages of heating.
   5. Record fan data.

3.9 ELECTRICAL COMPONENTS ASSOCIATED WITH MECHANICAL SYSTEMS:

A. Electric Resistance Heating Systems and Equipment:
   1. Measure full load amperage at full heating and design CFM and report.
   2. Electric heaters in an airstreams shall have entering and leaving air temperature measured and reported for all stages of heating.
   3. Verify lockout below minimum CFM.

B. Manual and Magnetic Starters:
   1. Check all new and existing thermal overloads. Identify improperly protected equipment in report. Furnish and exchange thermals as required for proper motor protection.
   3. Two-speed Starters: In addition to the above, set time delay between changes of speeds for proper operation.
      a. Verify windings of motor and starter is compatible prior to starting any equipment.

C. Variable frequency drives:
   1. Coordinate balance process with equipment manufacturer start-up representative.
   2. Record nameplate data.
   3. Record motor overload setting.
   4. Record full load amps.
3.10 CONTROL SYSTEMS AND EQUIPMENT:

A. General:

1. Operate all temperature control systems with the temperature control contractor’s representative for proper sequence of operation. Be responsible for calibration of flow measurement devices used as input to the temperature control system. All air system flow measurement stations including VAV terminals shall be calibrated against a Pitot tube traverse or air diffuser capture hood. Balancing Contractor shall assure accuracy of all flow measurement devices or shall report their failure to be accurate.

2. Work with the Controls Contractor to set minimum outside air damper positions.

3. Work with the Controls Contractor to optimize VAV duct static pressure, VFD pump hydronic system pressure differential and building pressure.

3.11 LIFE SAFETY SYSTEMS AND EQUIPMENT:

A. Smoke Pressurization/Exhaust/Evacuation Mode:

1. Balance and report measurements of Section 3.3 in this operational mode.

2. Perform smoke pressurization/evacuation tests in all zones. Doors shall be positioned to simulate normal conditions.

3. Coordinate with the Fire Department/Authority Having Jurisdiction, Owner and Engineer for smoke test witnessing.

4. Coordinate with the Fire Department/Authority Having Jurisdiction for additional testing requirements. Complete and submit any documentation for Fire Department/Authority Having Jurisdiction final acceptance.

B. Fire/Smoke Dampers and Detection Systems:

1. Verify that each fire/smoke damper closes when the associated duct or space detector is tripped. Verify that air handlers shut down and outside air dampers close as dictated by the control sequence.

2. Verify that air supply units shut down when smoke is detected by the associated duct detector. Verify that outside air dampers and system fire/smoke dampers close as dictated by the control sequence.

3. Report any detectors or dampers that are malfunctioning. Report any discrepancies from the control sequence.

C. Engine Generator Systems and Equipment:

1. For remote radiators, measure and report steady state radiator system flow rate, supply water temperature and return water temperature.


Record pressure relationship of generator room to adjacent spaces and outside.
3. Verify correct sequence of operation of all intake and discharge dampers, supply/exhaust fans, etc.

3.12 SOUND AND VIBRATION:

A. Sound Inspection and Testing:

1. Prior to sound testing, all equipment that can potentially impact sound testing shall be put into operation. Examples include fan coil units, humidifiers, air handling units, and equipment in adjacent mechanical spaces. VFD systems shall be placed at 80% of full speed.

2. Prior to sound testing the mechanical test and balance of all systems shall be completed.

3. Report audible tonal characteristics such as whine, whistle, hum or rumble. Also report time varying sound levels or beats induced from aerodynamic instability, perform this for all rooms.

4. Perform sound testing on all rooms/the following rooms within the project area.

5. Measure cooling tower sound output (DBA). Perform this at full speed for VFD units.


7. Measure and report noise levels (DBA) at the following locations:
   a. At the property line closest to intake and discharge louvers.
   b. At the property line closest to rooftop and at grade equipment such as cooling towers and chillers.
   c. On the roof of adjacent buildings overlooking rooftop equipment within the project area.

B. Vibration Inspection and Testing:

1. Prior to vibration testing, all equipment shall be put into operation. On variable speed equipment, testing shall occur at low, medium and high speeds.

2. Prior to vibration testing, the mechanical test and balance of all systems shall be completed.

3. Report excessive vibrations from any equipment. Inspect upstream and downstream duct and piping systems and report excessive vibrations.

4. Verify that all spring and elastomeric isolation systems are installed “free-floating” and are not short circuited to structure by obstructions.

5. Perform a stethoscope check on all accessible bearings. Report excessive vibration or noise.

6. Obtain undeflected isolator spring lengths from shop drawings for each piece of equipment, report. Measure and report distance of spring isolator deflection for each of equipment. Measure and report disturbing frequency (Hz) for each piece of equipment.

7. Measure and report motor running speed and driven equipment running speed for each component.
8. Measure and report horizontal, vertical and axial RMS velocity (in./sec.) at equipment structure or bearings.

9. Measure and report horizontal, vertical and axial frequency (Hz.) at equipment structure or bearings.

10. Measure and report RMS velocity (in./sec.) and frequency for the following surfaces in all three axis’s:


3.13 REPORT OF WORK:

A. The Testing and Balancing Contractor shall submit six (6) bound copies of the final testing and balancing report at least fifteen (15) calendar days prior to the Mechanical Contractor’s request for final inspection.

B. A complete reduced set of mechanical contract drawings (showing each system) shall be included in the report with all equipment, flow measuring devices, terminals (outlets, inlets, coils, fan coil units, schedules, etc.) clearly marked and all equipment designated. The test and balance contractor can obtain drawing files from Cator, Ruma, & Associates for development of these drawings. These drawings shall be developed from the system schematic drawings submitted in Preliminary Systematic Procedures.

C. Data shall be reported per Part 3 of this Section on standard NEBB forms. Generate custom forms that contain the information in this Section when a standard NEBB form does not exist for a piece of equipment. All NEBB forms shall be fully filled out for this report. When additional information is required by this Section, it shall be provided. Report forms with design columns filled out shall be used from the Preliminary Systematic Procedure report submitted previously.

D. The report shall include all test and balance data as well as information on any discrepancy from specifications or performance standards. All discrepancies shall be included in a separate section. As a minimum, the following items shall be included:

1. Belt and drive sheave information (as installed and as changed), fan nameplate information, motor nameplate information, and amperage and voltage to all motors (in various operating modes where applicable). Also, maximum and minimum RPM settings on VFD units.

2. Static pressure drops across all components of the air systems. Static pressure profile for each air handling unit system.

3. Required and final balanced CFM at each system terminal unit. Include the terminal size, inlet static pressure, temperature and velocities read to attain the required CFM.

4. Pump and motor nameplate information, amperage and voltage to all motors, flow and pressure drop across all system terminal, pressure rise across all system terminals, pressure rise across the pump in psi and feet of head, both operating and shut-off, and maximum operating GPM.

5. Refrigerant system operating amperages, pressures and temperatures.

6. Overload protection data for all motors shall be recorded. Starter and/or VFD brand, model, enclosure type, installed overload devices, original ratings and set points (and revised device ratings and set points when applicable) shall be recorded. If the starters (and/or VFDs) were furnished by the mechanical contractor, the overloads shall be verified and changed to the
correct size when necessary, and so noted in the report. If the starters were furnished by the electrical contractor, the correct overload device sizes and settings shall be noted in the report and the electrical contractor shall be advised of all discrepancies.

E. The report shall include a list of all equipment used in the testing and balancing work. This list shall closely resemble the list submitted with the Preliminary Systematic Procedures report with any discrepancies accounted for.

F. Report systems for excessive sound and vibration per the sound and vibration inspection and testing portions of this specification.

G. Substantial completion of this project will not take place until a satisfactory report is received. The Testing & Balancing Contractor shall respond and correct all deficiencies within seven (7) days of receiving the Engineer’s written review of the balancing report. Failure to comply will result in holding retainage of the final payment until all items have been corrected to the satisfaction of the Engineer.

H. The report shall be signed by the supervising registered professional engineer and affixed with their registration stamp, signed and dated in accordance with state law.

3.14 FIELD VERIFICATION:

A. Upon request of the Owner or Engineer, a representative of the balancing firm performing the work shall demonstrate to him fluid flow quantities shown in the report by reading back outlets or terminals selected at random. It is understood that the operating mode of the system shall be the same for readback as it was during balancing and the number of readings verified will not exceed 10% of the total in the report.

B. When deemed necessary by the Owner or Engineer, the balancing firm shall run temperature, pressure, and/or humidity recordings, and shall be prepared to verify any of the report test results in the presence of the Owner and/or Engineer when requested.

3.15 GUARANTEE OF WORK:

A. The Testing & Balancing Contractor shall guarantee the accuracy of the tests and balance for a period of 90 days from date of final acceptance of the test and balance report. During this period, the Testing & Balancing Contractor shall make personnel available at no cost to the Owner to correct deficiencies that may become apparent in the system balance.

END OF SECTION 23 05 93
SECTION 23 07 00
MECHANICAL INSULATION

PART 1 - GENERAL

1.1 QUALITY ASSURANCE:
A. Insulation shall meet the more strict requirements of the latest versions of the International Energy Conservation Code and ASHRAE 90.1.
B. Manufacturer's Qualifications: Firms regularly engaged in manufacture of mechanical insulation products and systems, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 3 years.
C. Installer's Qualifications: Firm with at least 5 years successful installation experience on projects with mechanical insulations similar to that required for this project.
D. Flame/Smoke Ratings: Provide composite mechanical insulation (insulation, jackets, coverings, sealers, mastics and adhesives) with flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E 84 (NFPA 255) method. In addition, the products, when tested, shall not drip flame particles, and flame shall not be progressive. Provide Underwriters Laboratories Inc., label or listing, or satisfactory certified test report from an approved testing laboratory to prove that fire hazard ratings for materials proposed for use do not exceed those specified.
E. Insulation Materials: Non-combustible as defined in NFPA Pamphlet 220 and UL listed or labeled.

1.2 SUBMITTALS:
A. Product Data: Submit manufacturer's technical product data and installation instructions for each type of mechanical insulation. Submit schedule showing manufacturer's product number, k-value, thickness, density, and furnished accessories for each mechanical system requiring insulation. Submit detail product information and installation information for all jacketing systems specified in this section.

1.3 DELIVERY, STORAGE, AND HANDLING:
A. Deliver insulation, coverings, cements, adhesives, and coatings to site in containers with manufacturer's stamp or label, affixed showing fire hazard indexes of products.
B. Protect insulation against dirt, water, and chemical and mechanical damage. Do not install damaged or wet insulation; remove from project site.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:
A. Manufacturer: Subject to compliance with requirements, provide product by one of the following:
1. Mechanical Insulation:
   a. Armaflex
   b. Johns Manville Corp.
   c. Owens-Corning Fiberglas Corp.
   d. Knauf Fiber Glass
   e. Manson
2.2 PIPING INSULATION MATERIALS:

A. Fiberglass Piping Insulation: ASTM C 547, Class 1 unless otherwise indicated. "K" factor shall be maximum 0.24 at 75 degrees F. mean temperature, jacket with tensile strength of 35 lbs/in, mullen burst 70 psi, beach puncture 50 oz. in/in, permeability .02 perm factory applied vapor barrier jacket and adhesive self-sealing lap joint.

B. Cellular Glass Piping Insulation: ASTM C 552, Type II, Class 2. "K" factor shall be maximum 0.29 at 75 degrees F mean temperature.

C. Calcium Silicate Piping Insulation: ASTM C 533, Type I. "K" factor shall be maximum 0.45 at 500 degrees F. mean temperature, compression strength 200 psi for 5 percent compression, transverse strength 200 psi for 5 percent compression, flexural strength 60 psi.

D. Flexible Closed Cell Piping Insulation: ASTM C 534, Type I. "K" factor shall be maximum 0.27 at 75 degrees F. mean temperature, with a water vapor permeability of 0.10 perm inches or less. Insulation shall be pre-installed on piping, or un-slit to be slipped over piping as a single piece.

E. Flexible Thermal Ceramic Insulation [Fiber Retractory, Ceramic Fiber]: "K" factor shall be a maximum of 1.5 at 1500 degrees F mean temperature, 2000 degrees F temperature limit. Provide presized glass cloth jacketing material, not less than 7.8 ounces per square yard, or metal jacket at Installer's option, unless otherwise indicated.

F. Rigid Thermal Ceramic Insulating System: "K" factor shall be a maximum of 1.5 at 1500 degrees F mean temperature, 2000 degrees F temperature limit.

G. Jackets for Piping Insulation: ASTM C 921, Type I for piping with temperatures below ambient, Type II for piping with temperatures above ambient. Type I may be used for all piping at Installers option.

1. Fitting Covers: UV resistant PVC, pre-molded fitting covers, flame spread 25, smoke developed 50. PVC tape for cold systems, serrated tacks or PVC tape for hot systems.
2. Aluminum Jacketing: Manufactured from T3003 (or T/5005) H14 to H19 aluminum alloy with 3/16" corrugations and shall have a factory attached 1 mil thick polyethylene moisture barrier continuously laminated across the full width of the jacketing. Jacketing shall be .016" thick minimum. Provide matching factory fabricated covers for 90 degrees and 45 degrees elbows, tee fittings, flange fittings valve bodies, blind ends, reducers and other fittings necessary to make the covering system complete, waterproof and weatherproof. All jacketing shall be color coated baked on polyester finish, color selected by Architect.

3. PVC Jacketing: UV resistant PVC, 30 mil thick, flame spread 25, smoke developed 50, factory cut and curled to fit O.D. of insulated pipe. Solvent weld adhesive for sealing joints and seams.

H. Staples, Bands, Wires, and Cement: As recommended by insulation manufacturer for applications indicated.

I. Adhesives, Sealers, and Protective Finishes: As recommended by insulation manufacturer for applications indicated and additional finishes as specified.

### 2.3 DUCTWORK INSULATION MATERIALS:

A. Rigid Fiberglass Ductwork Insulation: ASTM C 612, Class 1, 450 degrees F temperature limit, density of 3 pcf. "K" value shall be maximum 0.23 at 75 degrees F. mean temperature, facing of 7 mil, foil reinforced with glass mesh and laminated to 40 lb kraft.

B. Round Surface Semi-Rigid Fiberglass Blanket Insulation: ATSM C 612, Class 1, 450 degrees F temperature limit, 2.5 PCF density "K" value of .25 max at 75 degrees F mean temp, foil-skrim-kraft facing. Orientation of fibers shall be perpendicular to facing to facilitate application on round surfaces.

C. Flexible Fiberglass Ductwork Insulation: ASTM C 553, Type I, 3/4 lbs per cu. ft. density. "K" value shall be maximum 0.25 at 75 degrees F. mean temperature, 250 degree F temperature limit, vapor transmission rating shall not exceed 0.02 perms, facing of .7 mil foil reinforced with glass mesh and laminated to 40 lb kraft.

D. Flexible closed cell elastomeric insulation: ASTM C534, Type I, "K" value shall be a maximum 0.27 at 75 degrees F mean temp, 220 degrees F Temperature limit, water vapor permeability rating of 0.10 perm inches or less.

E. Jackets for Ductwork Insulation: ASTM C 921, Type I for ductwork with temperatures below ambient; Type II for ductwork with temperatures above ambient.

   1. Aluminum Jacketing: The jacketing shall be manufactured from T3003 (or T/5005) H14 to H19 aluminum alloy with 3/16 inch corrugations and shall have a factory attached 1 mil thick polyethylene moisture barrier continuously laminated across the full width of the jacketing. Jacketing shall be .016 inches thick minimum. Where available, provide matching factory fabricated covers for 90 degrees and 45 degrees elbows, tee fittings, branch fittings, reducers and other fittings necessary to make the covering system complete, waterproof and weatherproof. All jacketing shall be color coated baked on polyester finish, color selected by Architect.

F. Ductwork Insulation Accessories: Provide staples, bands, wires, tape, anchors, corner angles and similar accessories as recommended by insulation manufacturer for applications indicated.

G. Ductwork Insulation Compounds: Provide cements, adhesives, coatings, sealers, protective finishes and similar compounds as recommended by insulation manufacturer for applications indicated.

### 2.4 EQUIPMENT INSULATION MATERIALS:
A. Rigid Fiberglass Equipment Insulation: ASTM C 612, Class 2. "K" factor shall be maximum 0.28 at 200 degrees F. mean temperature, 3.0 lb. density, 850 degrees F temperature limit.

B. Flexible Fiberglass Equipment Insulation: ASTM C 553, Type I, "K" factor shall be maximum 0.45 at 250 degrees F. mean temperature. 850 degrees F temperature limit.

C. Calcium Silicate Equipment Insulation: ASTM C 533, Type I, Block. "K" factor shall be maximum 0.87 at 1000 degrees F. mean temperature, compression strength 200 psi for 5 percent compression, transverse strength 60 psi.

D. Flexible closed cell elastomeric insulation: ASTM C534, Type I, "K" valve shall be a maximum of 0.27 at 75 degrees F mean temp, 220 degrees F temperature limit, water vapor permeability of 0.10 perm inches or less.

E. Jacketing Material for Equipment Insulation: Provide pre- sized glass cloth jacketing material, not less than 7.8 ounces per square yard, or metal jacket at Installer's option, except as otherwise indicated.

F. Equipment Insulation Compounds: Provide adhesives, cements, sealers, mastics and protective finishes as recommended by insulation manufacturer for applications indicated.

G. Equipment Insulation Accessories: Provide staples, bands, wire, wire netting, tape, corner angles, anchors and stud pins as recommended by insulation manufacturer for applications indicated.

2.5 SOUND LAGGING/INSULATION:

A. Flexible Fiberglass & Vinyl Sound Insulation: 1.0 PSF, .090 inch thick mylar feed vinyl loaded barrier, tested to 400psi tensile strength. Absorber material, foil covered fiberglass laminated on vinyl barrier,. 40 PSF, 2 inch nominal thickness insulating value of R-8.0. Assembly flame/smoke index of 12.5/19.5 tested per Class A ASTME-84. Assembly sound tested per ASTME-90 for a 5Tlof 30 or greater. Rated for temperature between -20 degrees F & 350 degrees F. Provide soundseal B-10LAG/AFA-9 or approved equal.

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>125</th>
<th>250</th>
<th>500</th>
<th>1000</th>
<th>2000</th>
<th>4000</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-10 LAG 1 QFA-9</td>
<td>19</td>
<td>20</td>
<td>23</td>
<td>33</td>
<td>44</td>
<td>53</td>
</tr>
</tbody>
</table>

B. Sound lagging foil tape: 4” x 200’ rolls of matching foil tape by Soundseal.

C. Insulation for application over duct, piping & equipment.

2.6 SOUND LININGS:

A. Product: Fibrous glass, neoprene coated, stenciled NFPA.

B. Minimum Thickness:
   1. In ductwork: 1 inch
   2. In plenums: 2 inches

C. Minimum Density:
1. In ductwork: 1-1/2lb. per cu. ft.
2. In plenums: 3lb. per cu. ft.

D. Suitable for duct velocity of 6000 fpm. Lining shall meet erosion test method described in UL Publication No. 181.

PART 3 - EXECUTION

3.1 INSPECTION:

A. Examine areas and conditions under which mechanical insulation is to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

B. Workmanship shall be first class and of the highest quality, poor installation or bad appearance as determined by the engineer shall be due cause to reject the entire project in whole and retainage will be withheld until corrective action is completed to the engineer's satisfaction.

3.2 HVAC PIPING SYSTEM INSULATION:

A. Insulation Omitted: Omit insulation on steam condensate piping between steam trap and union; and on hot piping unions, flexible connections, and expansion joints. Insulation may be omitted inside of cabinet unit heaters, convectors and fan coils for hot piping. Cold piping insulation inside fan coil unit cabinet may be omitted provided piping is located over drain pan. Hot and cold piping routed inside air handler units shall be insulated. Omit insulation on strainers in heating water strainers operating below 200 degrees F.

B. Heat Traced Piping:

1. Application Requirements: Insulate the following sub-zero HVAC piping systems:
   a. Piping exposed to freezing which is specified with heat cable.

2. Insulate each piping system specified above with the following types and thicknesses of insulation:
   a. Fiberglass: 1-1/2 inch thick for pipe sizes up to and including 1-1/2 inch, 2 inch thick for pipe sizes 2 inches and above.
   b. Above Ground, Exterior - Cellular Glass: 1-1/2 inches thick for pipe sizes up to and including 2 inch, 2 inches thick for pipe sizes over 2 inches.

C. Cold Piping (40 degrees F (4.4 degrees C) to ambient):

1. Application Requirements: Insulate the following cold HVAC piping systems:
   a. Chilled water supply and return piping.
   b. Cold condensate drain piping.
   c. Condenser water supply and return piping when used with plate and frame or cooling coil applications.
   d. Run-around heat recovery supply and return piping.
   e. Process cooling supply and return piping.

2. Insulate each piping system specified above with the following types and thicknesses of insulation:
   a. Fiberglass: 1 inch thick for pipe sizes up to and including 1-1/2 inch, 1-1/2 inch thick for pipe sizes over 1-1/2 inches.
b. Exterior, Above Ground - Cellular Glass: 1-1/2 inch thick for pipe sizes up to and including 1-1/2 inch, 2 inch thick for pipe sizes over 1-1/2 inches.

c. Below Ground - Flexible Elastomeric: 1/2 inch thickness for pipe sizes up to 2 inches.

D. Heating System Piping (to 200 degrees F (90 degrees C)):

1. Application Requirements: Insulate the following heating piping systems:
   a. Hot water supply and return piping.
   b. Low pressure steam vent & relief piping.
   c. Boiler feedwater piping.
   d. Blowdown piping.

2. Insulate each piping system specified above with the following type and thicknesses of insulation:
   a. Fiberglass: 1 inch thick for pipe sizes up to and including 1-1/2 inch, 2 inch thick for pipe over 1-1/2 inches.
   b. Above Ground Exterior - Cellular Glass: 2 inches thick for pipe sizes up to and including 8 inches, 2-1/2 inch thick for pipe sizes 8”.

E. High Temperature, Low Pressure Piping (200 to 250 degrees F (90 to 120 degrees C)):

1. Application Requirements: Insulate the following hot low pressure HVAC piping.
   a. HVAC high temperature (200 to 250 degrees) hot water supply and return piping.
   b. Low pressure steam (up to 15 psig).
   c. Steam condensate piping (all pressures).

2. Insulate each piping system specified above with the following type and thicknesses of insulation:
   a. Fiberglass: 1-1/2 inch thick for pipe sizes up to and including 1-1/2 inch, 3 inch thick for pipe sizes 2 inches and over.
   b. Provide factory made removable covers for valves, strainers, expansion joints and bucket traps.
   c. Above Ground, Exterior - Cellular Glass: 2-1/2 inches thick for pipe sizes up to and including 2 inch, 3 inch thick for pipe size 2-1/2 inches through 6 inches, and 5 inches thick for pipe sizes over 8 inches.

F. High Temperature, Medium and High Pressure Piping (250 to 350 degrees F (120 to 175 degrees C)):

1. Application Requirements: Insulate the following hot high pressure HVAC piping:
   a. Medium and High pressure (16 to 80 psig) steam piping.

2. Insulate each piping system specified above with the following type and thicknesses of insulation:
   a. Fiberglass: 1-1/2 inches thick for pipe sizes up to and including 1 inch, 2 inches thick for pipe sizes 1-1/4 inch through 1-1/2 inches, and 3 inches thick for pipe sizes over 1-1/2 inches.
b. Provide factory made removable covers for valves, strainers, expansion joints and bucket traps.

c. Exterior, Above Ground - Cellular Glass: 3 inches thick for pipe sizes up to and including 1 inch, 4 inches thick for pipe size 1-1/4 inch through 4 inches, and 5 inches thick for pipe sizes over 4 inches.

3.3 DUCTWORK SYSTEM INSULATION:

A. Insulation Omitted: Do not insulate fibrous glass ductwork, or lined ductwork.

B. Application Requirements: Insulate the following ductwork:

1. Outdoor air intake ductwork and plenums between air entrance and fan inlet or HVAC unit inlet.
2. Mixed air ductwork and plenums between air entrance and fan inlet or HVAC unit inlet.
3. HVAC supply ductwork between fan discharge, or HVAC unit discharge, and room terminal outlet unless ductwork is specified to be lined.
4. HVAC return ductwork in unconditioned spaces or exterior; except omit insulation when ductwork is specified to be lined.
5. HVAC plenums and unit housings not pre-insulated at factory or lined.
6. Rigid oval or round supply air ductwork.

C. Insulate each ductwork system specified above with the following types and thicknesses of insulation:

<table>
<thead>
<tr>
<th>APPLICATION</th>
<th>RIGID/ FIBERGLASS</th>
<th>FLEXIBLE FIBERGLASS</th>
<th>FLEXIBLE ELASTOMERIC**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interior; concealed; cold, hot or dual temperature duct</td>
<td>1” min. up to 2” as required to cover joints &amp; reinforcements</td>
<td>1-1/2”</td>
<td>1”</td>
</tr>
<tr>
<td>Interior; exposed within conditioned finished spaces; cold, hot, or dual temperature duct</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Interior; exposed within mechanical, electrical, storage, or other service areas; cold, hot, or dual temperature duct</td>
<td>1” min. up to 2” as required to cover joints and reinforcements</td>
<td>Not Allowed</td>
<td>1” min. up to 2” as required to cover joints and reinforcements with white finish. Provide white finish coat.</td>
</tr>
<tr>
<td>Exterior; hot or dual temperature duct, all return duct</td>
<td>Not Allowed</td>
<td>Not Allowed</td>
<td>2” with metal jacket</td>
</tr>
<tr>
<td>Unconditioned Attic; hot, cold, dual temperature, or return duct</td>
<td>1-1/2”</td>
<td>2”</td>
<td>1-1/2”</td>
</tr>
</tbody>
</table>

3.4 EQUIPMENT INSULATION:

A. Cold Equipment (Below Ambient Temperature):

1. Application Requirements: Insulate the following cold equipment:
a. Refrigeration equipment, including chillers, tanks and pumps, including any cold surfaces not factory insulated.
b. Condensate pans under chilled equipment.
c. Cold water storage tanks.
d. Cold and chilled water pumps.
e. Pneumatic water tanks.
f. Air separators.

2. Insulate each item of equipment specified above with the following types and thicknesses of insulation:
   a. Rigid Fiberglass: 1 inch thick for surfaces above 35 degrees F (2 degrees C) and 1-1/2 inch thick for surfaces 35 degrees F (2 degrees C) and lower.
   b. Flexible Elastomeric Sheet: ½ inch thickness for surface temperatures above 35 degrees F (2 degrees C), 1 inch thickness for surface temperatures below 35 degrees F (2 degrees C).

B. Hot Equipment (Above Ambient Temperature):
1. Application Requirements: Insulate the following hot equipment:
   a. Boilers (not pre-insulated at factory).
   b. Water heaters (not pre-insulated at factory)
   c. Heat exchangers.
   d. Condensate receivers.
   e. Hot water pumps operating over 200 degrees.
   f. Condensate pumps.
   g. Flash tanks.
   h. Air separators.
   i. Blow down separators.
   j. Feedwater storage tanks.

2. Insulate each item of equipment specified above with the following types and thicknesses of insulation:
   a. Fiberglass: 2 inch thick, except 3 inch thick for low-pressure boilers and steam-jacketed heat exchangers. Do not use for equipment above 450 degrees F (232 degrees C).
   b. Calcium Silicate: 3 inch thick, except 4 inch thick for diesel exhaust mufflers and 4-1/2 inches thick for low-pressure boilers and steam-jacketed heat exchangers.

3. Application Requirements: Insulate the following breechings and stacks:
   a. Breechings between heating equipment outlet and stack or chimney connection, except for double wall or factory insulated breechings.
   b. Stacks from bottom to top except for factory insulated stacks.

4. Insulate each breeching and stack specified above with the following types and thicknesses of insulation:
   a. Calcium Silicate: 4 inches thick (2 layers of 2 inch thickness).
3.5 INSTALLATION OF PIPING INSULATION:

A. General: Install insulation products in accordance with manufacturer's written instructions, and in accordance with recognized industry practices to ensure that insulation serves its intended purpose.

B. Install insulation on pipe systems subsequent to installation of heat tracing, testing, and acceptance of tests.

C. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with single cut piece to complete run. Do not use cut pieces or scraps abutting each other.

D. Clean and dry pipe surfaces prior to insulating. Butt insulation joints firmly together to ensure complete and tight fit over surfaces to be covered.

E. Maintain integrity of vapor-barrier jackets on cold pipe insulation, and protect to prevent puncture or other damage.
   1. Do not use staples or tacks on vapor barrier jackets.
   2. Seal vapor barrier penetrations with vapor barrier finish recommended by the manufacturer.
   3. Seal fitting covers with PVC tape.
   4. Cover all unions, check valves, and other in-line devices. Mark outer covering with indelible marker to identify item covered.

F. Neatly bevel and seal insulation at all exposed edges.

G. Cover valves, fittings and similar items in each piping system with equivalent thickness and composition of insulation as applied to adjoining pipe run. Install factory molded, precut or job fabricated units (at Installer's option) except where specific form or type is indicated.

H. Extend piping insulation without interruption through walls, floors and similar piping penetrations, except where otherwise indicated.

I. See equipment insulation for removable insulation on accessible piping components.

J. See Section 230529 for insulation inserts and shields. Butt pipe insulation against pipe hanger insulation inserts. For all piping apply wet coat of vapor barrier lap cement on butt joints and seal all joints and seams with 3 inch wide vapor barrier tape or band.

K. Flexible Elastomeric Piping Insulation:
   1. Install unslit, by slipping over piping prior to joining, or install pre-insulated soft copper tubing.
   2. Seal butt ends with adhesive.

L. Cellular Glass Insulation:
   1. Apply in a single layer. Secure to pipe with ½ inch wide aluminum bands.
   2. For indoor applications, apply all purpose Kraft paper/aluminum foil/vinyl coating jacket. Seal all lap and butt joints with self seal vapor barrier tape.
3. For outdoor applications, apply aluminum rubber/Tedlar jacketing as described below.

M. Calcium Silicate Insulation:

1. Apply in a single layer. Secure to pipe with 1/2 inch wide aluminum bands.

2. For indoor applications, provide canvas jacketing. Adhere joints of jacketing and provide a finish coat of sealant as recommended by the manufacturer.

N. Piping Exposed to Weather: Protect outdoor insulation from weather by installing aluminum rubber.

1. Jacketing shall be secured by 1/2 inch wide stainless steel bands located on 24 inch centers. All joints and seams shall be caulked with clear silicone. Locate all longitudinal seams at the bottom of piping to minimize joint exposure to weather. Contractor may propose pre-fabricated sealing and fastening systems, submit samples and product data for approval.

3.6 INSTALLATION OF DUCTWORK INSULATION:

A. General: Install insulation products in accordance with manufacturer's written instructions, and in accordance with recognized industry practices to ensure that insulation serves its intended purpose.

B. Flexible fiberglass shall be allowed to regain thickness upon removal from packaging prior to wrapping duct. Flexible fiberglass found to be over-tightened and/or compressed will be required to be replaced.

C. Install insulation materials with smooth and even surfaces.

D. Clean and dry ductwork prior to insulating. Butt insulation joints firmly together to ensure complete and tight fit over surfaces to be covered.

E. Maintain integrity of vapor-barrier on ductwork insulation, and protect it to prevent puncture and other damage.

1. Avoid the use of staples on vapor barrier jackets.

2. Seal vapor barrier penetrations with vapor barrier tape recommended by the manufacturer.

F. Extend ductwork insulation without interruption through walls, floors and similar ductwork penetrations, except where otherwise indicated.

G. Lined Ductwork: Except as otherwise indicated, omit insulation on ductwork where internal insulation or sound absorbing linings have been installed.

H. Flexible Fiberglass Insulation: Cut back insulation to provide a 2 inch facing overlap at all seams. Seams shall be stapled approximately 6 inches on center with outward clinching staples, then sealed with pressure-sensitive tape matching the facing and designed for use with duct insulation. The underside of ductwork 24 inches or greater shall be secured with mechanical fasteners and speed clips spaced approximately 18 inches on center. The protruding ends of the fasteners should be cut off flush after the speed clips are installed, and then sealed with the same tape as specified above.

I. Corner Angles: Except for oven and hood exhaust duct insulation, install corner angles on all external corners of insulation on ductwork in exposed finished spaces before covering with jacketing.

J. Adhere flexible elastomeric sheets to clean oil-free metal surface by compression fit method and full coverage of adhesive. Seal butt joints with same adhesive. For exterior ductwork, notch insulation at reinforcements and joint flanges to provide a smooth surface, unless the reinforcements or joints would
penetrate the insulation. Provide a minimum ½ inch cap over any penetrating item. Stagger all joints and seams on multi-layer insulation.

3.7 INSTALLATION OF EQUIPMENT INSULATION:

A. General: Install equipment thermal insulation products in accordance with manufacturer's written instructions, and in compliance with recognized industry practices to ensure that insulation serves intended purpose. Complete finishes as specified.

B. Install insulation materials with smooth and even surfaces and on clean and dry surfaces. Redo poorly fitted joints. Do not use mastic or joint sealer as filler for gaping joints and excessive voids resulting from poor workmanship.

C. Maintain integrity of vapor-barrier on equipment insulation and protect it to prevent puncture and other damage.

D. Do not apply insulation to equipment, mufflers, breechings, or stacks while hot.

E. Apply insulation using staggered joint method and double layer construction. Apply each layer of insulation separately.

F. Insulation board shall be cut and mitered to fit the contour of the vessel and shall be applied with edges tightly butted, joints staggered where two or more layers are necessary (due to available thickness of insulation) and secured with 1/2 inch x 0.015 inch galvanized steel bands on 12 inch centers or with weld pins or stick clips with washers on 18 inch centers.

G. Coat insulated surfaces with layer of insulating cement, cover the insulation, 1 inch galvanized wire mesh shall be tightly stretched in place with edges tied together and finished between two coats of insulating cement troweled to a hard finish (not less than 1/4 inch thick).

H. Do not insulate hot equipment ASME stamp and manufacturer's nameplate. Provide neatly beveled edge at interruptions of insulation.

I. Cold equipment requiring access: Provide removable section of insulation, fabricated from flexible elastomeric insulation, adhered to an aluminum jacket, and joined with velcro strips around entire perimeter. Reinforce removable section and adjoining insulation at attachment points. Removable insulation shall be provided for all equipment requiring periodic inspection, access or maintenance including:

1. Chilled water pump bodies.
2. Strainer basket access.
3. Heat exchanger (including chillers) tube access.

J. Hot equipment requiring access: Provide Teflon-coated, Velcro closure, removable insulation jacket.

Provide removable insulation for hot equipment requiring access with accessible components over 100 square inches or any component operating over 200 degrees including:

1. Steam condensate receivers and pumps.
2. Steam Strainers.
3. Steam pressure regulators.
4. Heat exchanger tube access.
5. Handhole/manhole/cleanout access.
K. Equipment Exposed to Weather: Protect outdoor insulation from weather by installation of aluminum jacketing, as recommended by manufacturer. On flexible elastomeric insulation, apply two (2) coats of manufacturer's approved U.V. resistant finish.

3.8 EXISTING INSULATION REPAIR:

A. Repair damaged sections of existing mechanical insulation, both previously damaged or damaged during this construction period. Use insulation, install new jacket lapping and sealed over existing.

3.9 PROTECTION AND REPLACEMENT:

A. Replace damaged insulation which cannot be repaired satisfactorily, including units with vapor barrier damage and moisture saturated units.

B. Protection: Insulation Installer shall advise Contractor of required protection for insulation work during remainder of construction period, to avoid damage and deterioration.

END OF SECTION 23 07 00
SECTION 23 08 00
COMMISSIONING START-UP

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. This section covers the general requirements for the Division 23 responsibilities and participation in the Commissioning process.
2. Mechanical system installation, startup, testing, balancing, preparation of O&M manuals, and operator training are the responsibility of the Division 21, 22, and 23, Contractor(s) with coordination, observation, verification, and Commissioning the responsibility of Division 1, Section 019113. The 019113 Commissioning process does not relieve Division 21, 22, and 23 from the obligations to complete all portions of the work in a satisfactory and fully operational manner.
3. Work of Division 23 includes:
   a. Factory Testing and startup of the equipment.
   b. Testing, adjusting, and balancing of hydronic and air systems.
   c. Cooperation with the University Commissioning Agent (UCA).
   d. Providing qualified personnel for participation in Commissioning tests.
   e. Providing equipment, materials, and labor as necessary to correct construction and/or equipment deficiencies found during the Commissioning process.
   f. Providing operation and maintenance manuals and as-built drawings to the Engineer and the University Commissioning Agent for verification.
   g. Providing assistance to the University Commissioning Agent to develop and edit system operating and maintenance procedure narratives.
   h. Providing training and demonstrations for the systems specified in this Division.

1.2 TRAINING

A. In addition to the requirements of Division 1, coordinate participation in the training of the Owner’s engineering and maintenance staff on each system and related components with the University Commissioning Agent. Training will be conducted with field demonstrations as appropriate, with system and component documentation and suitable classroom training aids. Training shall be completed by Factory personnel where indicated or by a Factory designated representative as a minimum.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. Provide test equipment as necessary for testing and startup of the mechanical equipment and systems.

2.2 TEST EQUIPMENT - PROPRIETARY

A. Proprietary test equipment, hardware, and software required by the equipment manufacturer for programming and/or startup, whether specified or not, shall be provided to the University Commissioning Agent at no cost by the manufacturer of the equipment. Manufacturer shall
provide the test equipment, demonstrate its use, and assist the University Commissioning Agent in the Commissioning process as needed. Proprietary test equipment (and software) shall become the property of the Owner upon completion of the Commissioning Process.

B. Controls contractor/manufacturer shall provide a printout of:

1. All software code
2. All user interface screens

PART 3 - EXECUTION

3.1 WORK PRIOR TO FUNCTIONAL TESTING

A. Complete all phases of work so the systems can be started, tested, balanced, and otherwise Commissioned. Division 23 has primary startup responsibilities for all mechanical systems so they are functional. This includes the complete installation of all equipment, materials, pipe, duct, wire, insulation, controls, etc., per the contract documents and related directives, clarifications, change orders, etc..

B. A commissioning plan will be developed with the Commissioning Agent. Division 23 contractors are obligated to assist the UCA in preparing the Commissioning plan by providing all necessary information pertaining to the actual equipment and installation. If Contractor-initiated system changes have been made that alter the Commissioning process, the Contractor will notify the University Project Manager (UPM) and University Commissioning Agent.

C. Complete and sign pre-functional test forms upon completion of each test and in advance of testing, adjusting, and balancing.

D. Specific pre-commissioning responsibilities of Division 23 include:

1. Factory startup services for the following items of equipment:
   a. Air handlers, fans, and heating equipment
   b. Heat Recovery/Reclaim Units
   c. Cooling towers
   d. Chemical water treatment
   e. Pumps
   f. Control systems
   g. Heat exchangers
   h. Chillers
   i. Boilers
   j. VFD’s
   k. Pressure independent air devices
   l. DDC controls and interface with all items stated here.
   m. Cage Racks, autoclaves, glass washers and sterilizers.
   n. Lab Air Monitor
   o. Pure Water Systems
   p. Laboratory Vacuum
   q. Laboratory Compressed Air
   r. Laboratory Natural Gas
   s. Laboratory Nitrogen Gas
   t. Laboratory Carbon Dioxide Gas
   u. Laboratory Specialty Gases as required.
   v. Medium Pressure steam system.
2. Normal startup services required to bring each system into a fully operational state. This includes but not limited to motor rotational check, belt and alignment checks, cleaning, filling, purging, leak testing, control sequences of operation, full-load and part-load performance, etc. The Commissioning Agent will not begin the verification process until each system is complete and tested, including normal Contractor startup.

E. Functional testing is normally intended to begin prior to completion of a system and/or subsystems and will be coordinated with the Division 23 Contractor. Start of Commissioning agent before system completion does not relieve the Contractor from completing those systems as per the schedule.

3.2 PARTICIPATION IN COMMISSIONING

A. Provide skilled technicians to start up and debug all systems within Division 23. These same technicians shall be made available to assist the Commissioning Agent in completing the Commissioning program. Work schedules, time required for testing, etc., will be requested by the University Commissioning Agent and coordinated by the Contractor. Contractor will ensure that the qualified technician(s) are available and present during the agreed-upon schedules and of sufficient duration to complete the necessary tests, adjustments, and/or problem resolutions.

B. Complete and sign functional performance test forms. Contractor is responsible for assuring the items checked off as complete are ready for Commissioning Agency verification. These should be completed on a daily basis.

C. System performance problems and discrepancies may require additional technician time, University Commissioning Agent time, reconstruction of systems, and/or replacement of system components. The additional technician time shall be made available for subsequent Commissioning periods until the required system performance is obtained.

D. The UCA reserves the right to question the appropriateness and qualifications of the technicians relative to each item of equipment, system, and/or subsystem. Qualifications of technicians will include expert knowledge relative to the specific equipment involved and a willingness to work with the Commissioning Agency to get the job done. Division 23 Contractor shall also provide adequate documentation and tools as necessary to start up and test the equipment, system, and/or subsystem.

E. The Testing, Adjusting and Balancing Contractor is considered an adjunct to the University Commissioning Agent, and will perform work that complements the UCA’s. The Testing, Adjusting and Balancing Contractor is to be a subcontractor to the general contractor.

3.3 WORK TO RESOLVE DEFICIENCIES

A. In some systems, maladjustments, misapplied equipment, and/or deficient performance under varying loads will result in additional work being required to commission the systems. This work will be completed under the direction of the University’s representative with input from the Contractor, equipment supplier, and University Commissioning Agent.

Whereas all members will have input and the opportunity to discuss, debate, and work out problems, the University Commissioning Agent will have final jurisdiction over any additional work done to achieve performance.

B. Division 23 corrective work must be performed to permit the timely completion of the Commissioning process. Experimentation to demonstrate system performance may be permitted.
If the University Commissioning Agent deems the experimentation work to be ineffective or untimely as it relates to the commissioning process, the University Commissioning Agent will notify the University Project Manager, indicating the nature of the problem, expected steps to be taken, and suggested deadline(s) for completion of activities.

3.4 ADDITIONAL COMMISSIONING

A. Additional Commissioning activities may be required after system adjustments, replacements, etc., are completed. The Contractor, suppliers, and University Commissioning Agent shall include a reasonable reserve to complete this work as part of their contractual obligations.

3.5 SEASONAL COMMISSIONING

A. Seasonal Commissioning pertains to testing under full-load conditions during peak heating and cooling seasons, as well as part-load conditions in the spring and fall. Initial Commissioning will be done as soon as contract work is completed, regardless of season. Subsequent Commissioning may be undertaken at any time thereafter to ascertain adequate performance during the different seasons.

B. Cooling equipment will be tested as close to summer design extremes as possible (subject to school schedule limitations) with a fully occupied building. Each Contractor and supplier will be responsible to participate in the initial and the alternate peak season tests of the systems as required to demonstrate performance.

C. Training will be hosted by the University Commissioning Agent and conducted by the Contractor(s) and Vendors. The Contractor will be responsible for highlighting system peculiarities specific to this project.

END OF SECTION 23 08 00
SECTION 23 0900
BUILDING AUTOMATION SYSTEM (BAS) GENERAL

PART 1 GENERAL

1.01 SECTION INCLUDES
A. General Requirements
B. Description of Work
C. Quality Assurance
D. System Architecture
E. Distributed Processing Units/Quantity and Location
F. Demolition and Reuse of Existing Materials and Equipment
G. Sequence of Work

1.02 RELATED DOCUMENTS
A. Section 23 0500 - Basic Mechanical Requirements.
B. Section 23 0913 – Building Automation System (BAS) Basic Materials, Interface Devices, and Sensors
C. Section 23 0902 - BAS Operator Interfaces
D. Section 23 0903 - BAS Field Panels
E. Section 23 0904 - BAS Communication Devices
F. Section 23 0905 - BAS Software and Programming
G. Section 23 0993 - Sequences of Operation
H. Section 23 0801 - BAS Commissioning

1.03 DESCRIPTION OF WORK
A. Contractor shall furnish and install a direct digital control and building automation system (BAS). The new BAS shall utilize electronic sensing, microprocessor-based digital control, and electronic actuation of dampers and valves to perform control sequences and functions specified. Refer also to control drawings, sequences of operation, and point lists.
B. Contractor shall provide new front end and service tools as a separate line item for UCB review.
C. The distributed digital control (DDC) and building automation system (BAS) defined in this specification shall interface with the University private VLAN, and shall utilize open communications. Towards this end, contractor shall provide a router/gateway(s) as necessary to facilitate all specified objects and services and have them configured/mapped as applicable.
D. The systems to be controlled under work of this section basically comprise air handling (supply, return exhaust) cooling, heating, hear reclaim, process cooling and process steam. This Section defines the manner and method by which these controls function.
E. All control work shall be installed by the BAS contractor, unless specified otherwise. Certain mechanical systems such as chillers, boilers, cooling towers, and energy recovery units are equipped with manufacturer furnished controls. All labor, materials, equipment, software, and services necessary for the installation of a complete integrated system shall be provided.
   1. For DD pricing, the CU Standard Controls Specification is included. The contractor shall cover the requirements of both specs with the understanding these specs will be merged.
2. The Control Contractor will be responsible for all installation, programming, commissioning, testing and performance verification.

3. The Controls Contractor will be responsible for providing all devices required for a complete operating control system.

4. Total quantity and type of control points shall consist of specifications, drawings and as required to complete the sequence of operation as specified. Additional points shall be provided as required to meet all sequence of operation functions, safeties and data base. The drawings and Specifications are not intended to show all details necessary to make the system complete and operable.

5. The Control Contractor shall be responsible for all phases of software design, all equipment, installation and warrant for the BAS. The Control Contractor shall be responsible for supplying and installing all necessary control devices for completing the BAS.

6. The system shall include all control device, valves, interlocks, field devices, hardware, software, automatic dampers, piping, fittings, wire, conduit, etc., as specified and required and connected so as to perform all functions and operate according to the specified sequences.

7. Provide electrical work as required, complying with requirements of Division 26 sections including, but not limited to raceways, wires, cables, electrical identification, supporting devices and electrical connections for equipment. Work includes, but is not limited to, the following:

   a) Interlock and control wiring between field-installed controls, indicating devices and unit control panels.

   b) The Contractor shall be responsible for all additional electrical and other costs involved to accommodate the temperature control system panel, motors and electrical devices requiring power which differs from the power requirements shown on the electrical drawings.

   c) Refer to Division 26 for mechanical/electrical coordination.

8. Control Contractor shall furnish & identify location requirements for all necessary control devices which may be installed by others including the following, but not limited to:

   a) Automatic control valves.

   b) Flow switches.

   c) Outside, return and exhaust air dampers for the supply fan/return fan systems.

   d) Modulating dampers.

   e) Required wells for insertion thermostats and/or temperature sensing wells.

   f) Pressure Sensors.

1.04 APPLICATION OF OPEN PROTOCOLS

A. Subject to the detailed requirements provided throughout the specifications, the BAS and digital control and communications components installed, as work of this contract shall be an integrated distributed processing system utilizing BACnet. System components shall communicate using
native BACnet in accordance with ASHRAE Standard 135 and current addenda and annexes, including all workstations, all building controllers, and all application specific controllers.

1.05 QUALITY ASSURANCE

A. **Product Line Demonstrated History**: The product line being proposed for the project must have an installed history of demonstrated satisfactory operation for a length of 5 years since date of final completion in at least 20 installations of comparative size and complexity. Documentation of this requirement with references shall be available upon request.

B. **Installer's Qualifications**: Firms specializing and experienced in control system installations for not less than 5 years. Firms with experience in DDC installation projects with point counts equal to this project and systems of the same complexity as those of this project. Experience starts with awarded Final Completion of previous projects. Documentation of this requirement with references shall be available upon request.

C. **Installer's Experience with Proposed Product Line**: Firms shall have specialized in and be experienced with the installation of the proposed product line for not less than three years from date of final completion on at least 5 projects of similar size and complexity. Submittals shall document this experience with references.

D. **Installer’s Field Coordinator and Sequence Programmer Qualifications**: Individual(s) shall specialize in and be experienced with control system installation for not less than 5 years. Proposed field coordinator shall have experience with the installation of the proposed product line for not less than 2 projects of similar size and complexity. Installer shall submit the names of the proposed individual at least one alternate for each duty. Submittals shall document this experience with references. The proposed individuals must show proof of the following training:
   1. **Product Line Training**: Individuals overseeing the installation and configuration of the proposed product line must provide evidence of the most advanced training offered by the Manufacturer on that product line for installation and configuration.
   2. **Programming Training**: Individuals involved with programming the site-specific sequences shall provide evidence of the most advanced programming training offered by the vendor of the programming application offered by the Manufacturer.

E. **Installer’s Service Qualifications**: The installer must be experienced in control system operation, maintenance and service. Installer must document a minimum 5 year history of servicing installations of similar size and complexity. Installer must also document at least a one year history of servicing the proposed product line.

F. **Installer’s Response Time and Proximity**
   1. Installer must maintain a fully capable service facility within a 45 mile radius of the project site. Service facility shall manage the emergency service dispatches and maintain the inventory of spare parts.
   2. Emergency response times are listed below in this section. Installer must demonstrate the ability to meet the response times.

G. **Installer’s Quality Assurance Plan**
   1. Installer must provide a description of their quality assurance operations from contract award through final delivery. The description shall include organizational responsibilities for each department represented within the execution of this document from installer’s to engineers, service technicians and management.

1.06 CODES AND STANDARDS

A. The following codes and standard intended to apply as applicable as not all will apply to all installations

B. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)

C. Electronics Industries Alliance
2. EIA-709.3-99: Free-Topology Twisted-Pair Channel Specification
3. EIA-232: Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange.
4. EIA-458: Standard Optical Fiber Material Classes and Preferred Sizes
6. EIA-472: General and Sectional Specifications for Fiber Optic Cable
7. EIA-475: Generic and Sectional Specifications for Fiber Optic Connectors and all Sectional Specifications
8. EIA-573: Generic and Sectional Specifications for Field Portable Polishing Device for Preparation Optical Fiber and all Sectional Specifications
9. EIA-590: Standard for Physical Location and Protection of Below-Ground Fiber Optic Cable Plant and all Sectional Specifications

D. Underwriters Laboratories

E. NEMA Compliance
1. NEMA 250: Enclosure for Electrical Equipment
2. NEMA ICS 1: General Standards for Industrial Controls.

F. NFPA Compliance
1. NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems" where applicable to controls and control sequences.
2. NFPA 70 National Electrical Code (NEC)

G. Institute of Electrical and Electronics Engineers (IEEE)
1. IEEE 142: Recommended Practice for Grounding of Industrial and Commercial Power Systems
2. IEEE 802.3: CSMA/CD (Ethernet – Based) LAN
3. IEEE 802.4: Token Bus Working Group (ARCNET – Based) LAN

1.07 DEFINITIONS
A. **Accuracy**: As stated in Section 23 0913, accuracy shall include combined effects of nonlinearity, non-repeatability and hysteresis.

B. **Advanced Application Controller (AAC)**: A device with limited resources relative to the Building Controller (BC). It may support a level of programming and may also be intended for application specific applications.

C. **Application Protocol Data Unit (APDU)**: A unit of data specified in an application protocol and consisting of application protocol control information and possible application user data (ISO 9545).

D. **Application Specific Controller (ASC)**: A device with limited resources relative to the Advanced Application Controller (AAC). It may support a level of programming and may also be intended for application-specific applications.
E. **BACnet/BACnet Standard:** BACnet communication requirements as defined by ASHRAE/ANSI 135-2004.

F. **BACnet Interoperability Building Blocks (BIBB):** A BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBS are combined to build the BACnet functional requirements for a device in a specification.

G. **Binding:** In the general sense, binding refers to the associations or mappings of the sources network variable and their intended opr required destinations.

H. **Building Automation System (BAS):** The entire integrated management and control system

I. **Building Controller (BC):** A fully programmable device capable of carrying out a number of tasks including control and monitoring via direct digital control (DDC) of specific systems, acting as a communications router between the LAN backbone and sub-LANs, and data storage for trend information, time schedules, and alarm data.

J. **Change of Value (COV):** An event that occurs when a measured or calculated analog value changes by a predefined amount (ASHRAE/ANSI 135-2004).

K. **Client:** A device that is the requestor of services from a server. A client device makes requests of and receives responses from a server device.

L. **Continuous Monitoring:** A sampling and recording of a variable based on time or change of state (e.g. trending an analog value, monitoring a binary change of state).

M. **Controller or Control Unit (CU):** Intelligent stand-alone control panel. Controller is a generic reference and shall include BCs, AACs, and ASCs as appropriate.

N. **Control Systems Server (CSS):** This shall be a computer (or computers) that maintains the systems configuration and programming database. This may double as an operator workstation.

O. **Direct Digital Control (DDC):** Microprocessor-based control including Analog/Digital conversion and program logic

P. **Functional Profile:** A collection of variables required to define a the key parameters for a standard application. As this applies to the HVAC industry, this would include applications like VAV terminal, fan coil units, and the like.

Q. **Facility Maintenance Information Technology (FMIT):** Reference to the facility’s Information Technology department, responsible for providing and maintaining all OI hardware.

R. **Gateway (GTWY):** A device, which contains two or more dissimilar networks/protocols, permitting information exchange between them (ASHRAE/ANSI 135-2004).

S. **Hand Held Device (HHD):** Manufacturer’s microprocessor based device for direct connection to a Controller.

T. **LAN Interface Device (LANID):** Device or function used to facilitate communication and sharing of data throughout the BAS

U. **Local Area Network (LAN):** General term for a network segment within the architecture. Various types and functions of LANs are defined herein.

V. **Local Supervisory LAN:** Ethernet-based LAN connecting Primary Controller LANs with each other and OWSSs and CSSs. See System Architecture below. This LAN can function as the Primary Controlling LAN.

W. **Master-Slave/Token Passing (MS/TP):** Data link protocol as defined by the BACnet standard. (ASHRAE/ANSI 135-2004).

X. **Open Database Connectivity (ODBC):** An open standard application-programming interface (API) for accessing a database developed. ODBC compliant systems make it possible to access
any data from any application, regardless of which database management system (DBMS) is handling the data.

Y. **Operator Interface (OI):** A device used by the operator to manage the BAS including OWSs, POTs, and HHDs.

Z. **Operator Workstation (OWS):** The user’s interface with the BAS system. As the BAS network devices are stand-alone, the OWS is not required for communications to occur.

AA. **Point-to-Point (PTP):** Serial communication as defined in the BACnet standard.

BB. **Portable Operators Terminal (POT):** Laptop PC used both for direct connection to a controller and for remote dial up connection.

CC. **Protocol Implementation Conformance Statement (PICS):** A written document, created by the manufacturer of a device, which identifies the particular options specified by BACnet that are implemented in the device (ASHRAE/ANSI 135-2004).

DD. **Primary Controlling LAN:** High speed, peer-to-peer controller LAN connecting BCs and optionally AACs and ASCs. Refer to System Architecture below.

EE. **Router:** A device that connects two or more networks at the network layer.

FF. **Secondary Controlling LAN:** LAN connecting AACs and ASCs, generally lower speed and less reliable than the Primary Controlling LAN. Refer to System Architecture below.

GG. **Server:** A device that is a provider of services to a client. A client device makes requests of and receives responses from a server device.

HH. **SQL:** Standardized Query Language, a standardized means for requesting information from a database.

II. **Smart Device:** A control I/O device such as a sensor or actuator that can directly communicate with the controller network to which it is connected. This differs from an ASC in that it typically deals only with one variable.

JJ. **University of Colorado at Boulder (UCB):** Owner of the facility.

KK. **UCB Ethernet:** Reference to the facility’s Information Technology network, used for normal business-related e-mail and Internet communication. Internet-based network connecting multiple facilities with a central data warehouse and server, accessible via standard web-browser.

LL. **XML (Extensible Markup Language):** A specification developed by the World Wide Web Consortium. XML is a pared-down version of SGML, designed especially for Web documents. It allows designers to create their own customized tags, enabling the definition, transmission, validation, and interpretation of data between applications and between organizations.

**1.08 FUNCTIONAL INTENT**

A. Throughout Sections 23 0900 through 23 0905, the Sequences of Operation, and Section 23 0801 detailed requirements are specified, some of which indicate a means, method or configuration acceptable to meet that requirement. Contractor may submit products that utilize alternate means, methods, and configurations that meet the functional intent. However these will only be allowed with prior approval by the University.

**1.09 SUBMITTALS**

A. Submit under provisions of Section 23 05 00.

B. Electronic Submittals: Control submittals and O&M information shall be provided in Adobe PDF or Microsoft Word format. Preferably documents will be converted from their native electronic format directly to a preferred format. Any documents scanned as images must be converted to a
searchable text format using OCR (Optical Character Recognition) and reduced in size prior to submission.

C. Qualifications: Manufacturer, Installer, and Key personnel qualifications as indicated for the appropriate item above. Include QA/QC plan for all phases (design, install, Cx, warranty) along with documentation of industry standard QA/QC practices followed.

D. Product Data: Submit manufacturer's technical product data for each control device, panel, and accessory furnished, indicating dimensions, capacities, performance and electrical characteristics, and material finishes. Also include installation and start-up instructions.

E. Shop Drawings: Submit shop drawings for each control system, including a complete drawing for each air handling unit, system, pump, device, etc. with all point descriptors, addresses and point names indicated. Each shop drawing shall contain the following information:

1. System Architecture and System Layout:
   a) One-line diagram indicating schematic locations of all control units, workstations, LAN interface devices, gateways, etc. Indicate network number, device ID, drawing reference number, and controller type for each control unit. All optical isolators, repeaters, end-of-line resistors, junctions, ground locations etc. shall be located on the diagram.
      Indicate device instance and MAC address for each CU. Indicate media, protocol, baud rate, and type of each LAN.
   b) Provide floor plans on Adobe PDF software locating all control units, LAN interface devices, gateways, etc. Include all WAN and LAN communication wiring routing, power wiring, power originating sources, and low voltage power wiring. Wiring routing as-built conditions shall be maintained accurately throughout the construction period and the drawing shall be updated to accurately reflect accurate, actual installed conditions.
      Indicate network number, device ID, address, device instance, MAC address, drawing reference number, and controller type for each control unit. Indicate media, protocol, baud rate, and type of each LAN. All optical isolators, repeaters, end-of-line resistors, junctions, ground locations etc. shall be located on the floor plans.

2. Schematic flow diagram of each air and water system showing fans, coils, dampers, valves, pumps, heat exchange equipment and control devices. Include verbal description of sequence of operation.

3. All physical points on the schematic flow diagram shall be indicated with names, descriptors, and point addresses identified as listed in the point summary table.

4. With each schematic, provide a point summary table listing building number and abbreviation, system type, equipment type, full point name, point description, Ethernet backbone network number, network number, device ID, object ID (object type, instance number). See Section 23 0905 - Part III for additional requirements.

5. Label each control device with setting or adjustable range of control.

6. Label each input and output with the appropriate range.

7. Provide a Bill of Materials with each schematic. Indicate device identification to match schematic and actual field labeling, quantity, actual product ordering number, manufacturer, description, size, voltage range, pressure range, temperature range, etc. as applicable.

8. Provide a Control Valve Schedule listing valve and actuator information including: size, Cv, design flow, design pressure drop, manufacturer, model number, close off rating, control signal, etc. Indicate normal positions of spring return valves.

9. Provide a Control Damper Schedule listing damper and actuator information including: size, material, blade arrangement, manufacturer, model number, control signal, etc. Indicate normal positions of spring return dampers.
10. Indicate all required electrical wiring. Electrical wiring diagrams shall include both ladder logic type diagram for motor starter, control, and safety circuits and detailed digital interface panel point termination diagrams with all wire numbers and terminal block numbers identified. Provide panel termination drawings on separate drawings. Ladder diagrams shall appear on system schematic. Clearly differentiate between portions of wiring, which are existing, factory-installed and portions to be field-installed.

11. Provide details of control panels, including controls, instruments, and labeling shown in plan or elevation indicating the installed locations. Provide panel layout drawing including power supply, control unit(s) and wiring terminals.

12. Sheets shall be consecutively numbered.

13. Each sheet shall have a title indicating the type of information included and the HVAC system controlled.

14. Table of Contents listing sheet titles and sheet numbers.

15. Provide a symbol legend and list of abbreviations.

F. Open Protocol Information
   1. BACnet Systems:
      a) BACnet object description, object ID, and device ID, for each I/O point.
      b) Documentation for any non-standard BACnet objects, properties, or enumerations used detailing their structure, data types, and any associated lists of enumerated values.
      c) Submit PICS indicating the BACnet functionality and configuration of each controller.

G. Control Logic Documentation
   1. Submit control logic program listings to document the control software of all control units.
   2. Include written description of each control sequence.
   3. Include test plan for each unique control program.
   4. Include control response, settings, setpoints, throttling ranges, gains, reset schedules, adjustable parameters and limits.

H. Operation and Maintenance Materials:
   1. Submit documents under provisions of Section 23 05 00. Documents shall be provided electronically as described above (1.10/B).
   2. Submit maintenance instructions and spare parts lists for each type of control device, control unit, and accessory.
   3. Include all submittals (product data, shop drawings, control logic documentation, hardware manuals, software manuals, installation guides or manuals, maintenance instructions and spare parts lists) in maintenance manual; in accordance with requirements of Division 1. Only include sections for equipment and software used on this project. Do not provide entire catalog of product data with extraneous information.
   4. Submit BAS User’s Guides (Operating Manuals) for each controller type and for all workstation hardware and software and workstation peripherals.
   5. Submit BAS advanced Programming Manuals for each controller type and for all workstation software.

I. Controls contractor shall provide University with all product line technical manuals and technical bulletins, to include new and upgraded products, by the same distribution channel as to dealers or branches throughout the warranty period of the project.

J. Manufacturers Certificates: For all listed and/or labeled products, provide certificate of conformance.
K. Product Warranty Certificates: UCB shall approve all warranty start dates. Coordinate and submit manufacturers product warranty certificates covering the hardware provided once approved.

1. Submit in accordance with Division 1 and 23 submittal requirements.

2. When the Architect/Engineer requires, the Contractor will resubmit with the corrected or additional submittal data. This procedure shall be repeated until all corrections are made to the satisfaction of the Engineer and the submittals are fully reviewed.

3. Contractor agrees that shop drawing submittals processed by the Architect/Engineer are not change orders, that the purpose of shop drawing submittals by the Contractor is to demonstrate to the Architect/Engineer that the Contractor understands the design concept, that he demonstrates his understanding by indicating which equipment and material he intends to furnish and install, and by detailing the fabrication and installation methods he intends to use. The Contractor shall be responsible for space requirements, configuration, performance, changes in bases, supports, structural members and openings in structure, and other apparatus that may be affected by their use.

4. Contractor further agrees that if deviations, discrepancies, or conflicts between shop drawing submittals and the contract documents in the form of design drawings and specifications are discovered either prior to or after shop drawing submittals are processed by the Architect/Engineer, the design drawings and specifications shall control and shall be followed. If alternates do not meet these requirements, it shall be this Contractor's responsibility to remove them and install material originally specified, at no cost to the Owner.

1.10 PROJECT RECORD DOCUMENTS
A. Submit documents under provisions of Section 23 05 00. Documentation shall be provided electronically as defined in section 1.10/B above.
B. Record copies of product data and control shop drawings updated to reflect the final installed condition.
C. Record copies of approved control logic programming and database on CD/DVD. Accurately record actual setpoints and settings of controls, final sequence of operation, including changes to programs made after submission and approval of shop drawings and including changes to programs made during specified testing.
D. Record copies of approved project specific graphic software on CD/DVD.
E. Record copies shall include individual floor plans with controller locations with all interconnecting wiring routing including space sensors, LAN wiring, power wiring, low voltage power wiring.
F. Provide record riser diagram showing the location of all controllers.

1.11 SYSTEM ARCHITECTURE
A. The system provided shall incorporate hardware resources sufficient to meet the functional requirements of these Specifications. The Contractor shall include all items not specifically itemized in these Specifications that are necessary to implement, maintain, and operate the system in compliance with the functional intent of these Specifications.
B. The system shall be configured as a distributed processing network(s) capable of expansion as specified below.
C. The system architecture shall consist of a Ethernet-based, wide area network (WAN), a single Local Area Network (LAN) or multi-leveled LANs that support BCs, AACs, ASCs, Operator Workstations (OWS), Smart Devices (SD), and Remote Communication Devices (RCDs) as applicable. The following indicates a functional description of the BAS structure.

1. **UC WAN**: Internet-based network connecting multiple facilities with a central data warehouse and server, accessible via standard web-browser. This is an existing infrastructure and contractor is not required to configure any components of this WAN. Refer to Section 23 0904 for requirements:

2. **Local Supervisory LAN**: The Local Supervisory LAN shall be an Ethernet-based, 100 Mbps LAN connecting Primary Control LANs and OWSs. The LAN serves as the inter-BC gateway and OWS-to-BC gateway and communications path. Contractor shall provide this as a dedicated LAN for the control system. LAN shall be IEEE 802.3 Ethernet over Fiber or Category 5 cable with switches and routers that support 100 Mbps throughput. Power-line carrier communication shall not be acceptable for communications.

The higher level layers of this network shall be BACnet as described below:

a) **BACnet Supervisory LAN**: BACnet/IP as defined in Addendum A (Annex J) of the BACnet standard, and shall share a common network number for the Ethernet backbone, as defined in BACnet. Point/Object naming conventions are specified in 23 0905 - Part III.

3. **Primary Controller LAN** (‘Primary LAN’): High-speed, peer-to-peer communicating LAN used to connect AACs, ASCs and Building Controllers (BCs) and communicate exclusively control information. Acceptable technologies include:

   a) Ethernet (IEEE802.3)

   b) ARCNET (IEEE802.4)

4. **Secondary Controller LAN** (‘Secondary LAN’): Network used to connect AACs, ASCs or SDs. These can be Master Slave/Token Passing or polling, in addition to those allowed for Primary Controller LANs. Network speed vs. the number of controllers on the LAN shall be dictated by the response time and trending requirements.

D. **Dynamic Data Access**: Any data throughout any level of the network shall be available to and accessible by all other devices, Controllers and OWS, whether directly connected or connected remotely.

E. **Remote Data Access**: Coordinate remote access connectivity with FMIT (Facilities Management Information Technology) department. The system shall support the following methods of remote access to the building data.

   **UCB uses Ethernet for campus wide BAS access. Special cases requiring dial-up connectivity will be addressed as needed by UCB.**

   1. **Browser-based access**: A remote user using a standard browser shall be able access all control system facilities and graphics with proper password. UC shall provide the required internet connection. The following paradigms are acceptable for browser-based access:

      a) Native Internet-based user interfaces (HTML, Java, XML, etc.) that do not require a plug-in. The user interface must be compatible with the most current stable version of the supporting software (Java, etc.) without requiring the user to downgrade to a lesser version.

   F. The communication speed between the controllers, LAN interface devices, and operator interface devices shall be sufficient to ensure fast system response time under any loading condition. In no case shall delay times between an event, request, or command initiation and its completion be greater than those listed herein. Contractor shall reconfigure LAN as necessary to accomplish these performance requirements. Generally requirements do not apply when a remote connection must be established via modem:
1. 5 seconds between a Level 1 (critical) alarm occurrence and enunciation at operator workstation.
2. 10 seconds between a Level 2 alarm occurrence and enunciation at operator workstation.
3. 20 seconds between and a Level 3-5 alarm occurrence and enunciation at operator workstation.
4. 10 seconds between an operator command via the operator interface to change a setpoint and the subsequent change in the controller.
5. 5 seconds between an operator command via the operator interface to start/stop a device and the subsequent command to be received at the controller.
6. 10 seconds between a change of value or state of an input and it being updated on the operator interface.
7. 10 seconds between an operator selection of a graphic and it completely painting the screen and updating at least 10 points.

G. **Control Systems Server (CSS):** This shall be a computer (or computers) that maintain the systems configuration and programming database. This server may operate virtually under the supervision of FMIT. It shall hold the backup files of the information downloaded into the individual controllers and as such support uploading and downloading that information directly to/from the controllers. It shall also act as a control information server to non-control system based programs. It shall allow secure multiple-access to the control information. Refer to Section 23 0902 - BAS Operator Interfaces for its requirements.

H. The Operator Interface shall provide for overall system supervision, graphical user interface, management report generation, alarm annunciation, and remote monitoring. Refer to Section 23 0902 – BAS Operator Interfaces.

I. The BCs, AACs, ASCs, and SDs shall monitor, control, and provide the field interface for all points specified. Each BC, AAC, or ASC shall be capable of performing all specified energy management functions, and all DDC functions, independent of other BCs, AACs, or ASCs and operator interface devices as more fully specified in Section 23 0903 - BAS Field Panels.

J. Interruptions or fault at any point on any Primary Controller LAN shall not interrupt communications between other nodes on the network. If a LAN is severed, two separate networks shall be formed and communications within each network shall continue uninterrupted.

K. All line drivers, signal boosters, and signal conditioners etc. shall be provided as necessary for proper data communication.

### 1.12 WARRANTY MAINTENANCE

A. Contractor shall warrant all products and labor for a period of two years after Final Acceptance by UCB. Provide unit pricing for additional warranty years at discretion of UCB.

B. The University reserves the right to make changes to the BAS during the warranty period. Such changes do not constitute a waiver of warranty. The Contractor shall warrant parts and installation work regardless of any such changes made by the University, unless the Contractor provides clear and convincing evidence that a specific problem is the result of such changes to the BAS. Any disagreement between the University and the Contractor on such matters shall be subject to resolution through the contract ‘Disputes’ clause.

C. At no cost to the University, during the warranty period, the Contractor shall provide maintenance services for software and hardware components as specified below:

1. Maintenance services shall be provided for all devices and hardware specified in sections 23 0913 through 23 0904. Service all equipment per the manufacturer’s recommendations. All devices shall be calibrated within the last month of the warranty period.

2. Emergency Service: Any malfunction, failure, or defect in any hardware component or failure of any control programming that would result in property damage or loss of comfort
control shall be corrected and repaired following notification by the University to the Contractor.

a) Response by telephone to any request for service shall be provided within one (1) hour of the University's initial telephone request for service.

b) In the event that the malfunction, failure, or defect is not corrected through the telephonic communication, at least one (1) hardware and software technician, trained in the system to be serviced, shall be dispatched to the University's site within two (2) hours of the University's initial telephone request for such services, as specified.

3. Normal Service: Any malfunction, failure, or defect in any hardware component or failure of any control programming that would not result in property damage or loss of comfort control shall be corrected and repaired following telephonic notification by the University to the Contractor.

a) Response by telephone to any request for service shall be provided within two (2) working hours (contractor specified 40 hr per week normal working period) of the University's initial telephone request for service.

b) In the event that the malfunction, failure, or defect is not corrected through the telephonic communication, at least one (1) hardware and software technician, trained in the system to be serviced, shall be dispatched to the University's site within three (3) working days of the University's initial telephone request for such services, as specified.

4. Telephonic Request for Service: Contractor shall specify a maximum of three telephone numbers for University to call in the event of a need for service. At least one of the lines shall be attended at any given time at all times. Once contacted a technician shall respond to every call within 15 minutes.

5. Technical Support: Contractor shall provide technical support by telephone throughout the warranty period.

6. Preventive maintenance shall be provided throughout the warranty period in accordance with the hardware component manufacturer's requirements.

1.13 DELIVERY, STORAGE, AND HANDLING
A. Provide factory-shipping cartons for each piece of equipment and control device. Maintain cartons during shipping, storage and handling as required to prevent equipment damage, and to eliminate dirt and moisture from equipment. Store equipment and materials inside and protect from construction work and weather.

1.14 LISTING AND LABELING
A. The BAS and components shall be listed by Underwriters Laboratories (UL 916) as an Energy Management System.

PART 2 PRODUCTS

2.01 MATERIALS AND EQUIPMENT
A. Materials shall be new, the best of their respective kinds without imperfections or blemishes and shall not be damaged in any way. Used equipment shall not be used in any way for the permanent installation except where drawings or specs specifically allow existing materials to remain in place.

2.02 UNIFORMITY
A. To the extent practical, all equipment of the same type serving the same function shall be identical and from the same manufacturer
PART 3   EXECUTION

3.01 INSPECTION
A. Examine areas and conditions under which control systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.02 INSTALLATION OF CONTROL SYSTEMS
A. General: Install systems and materials in accordance with manufacturer's instructions, roughing-in drawings and details shown on drawings.
B. Refer to additional requirements in other sections of this specification.

3.03 CONTROL PANELS, CONTROLLER QUANTITY AND LOCATION
A. Control panels shall consist of one or multiple controllers to meet requirements of this specification. Control panels shall be wall mounted within mechanical equipment rooms. In no case shall panels, other than terminal unit controllers, be located above ceilings. Control panels for lighting control may be located in the electrical equipment room served by the control panel only with prior approval from UCB.
B. Restrictions in applying controllers are specified in Section 23 0903: BAS Field Panels. This Contractor shall extend power to the control panel from an acceptable power panel. If the control contractor wishes to further distribute panels to other locations, control contractor is responsible for extending power to that location also. Furthermore, contractor is responsible for ensuring adequate locations for the panels that do not interfere with other requirements of the project and maintain adequate clearance for maintenance access.
C. It is the Contractor's responsibility to provide enough controllers to ensure a completely functioning system, according to the point list and sequence of operations.
D. For rooftop AHUs and ERUs, controllers rated for use outside the building envelope shall be mounted inside the unit casings. If adequate space is not available for installation of the controllers per the manufacturer's recommendations, they shall be installed in NEMA4X enclosures adjacent to the unit served. For all other controllers serving rooftop equipment coordinate with UCB for control panel location, typically within the building envelope directly below equipment served in an accessible location.
E. Controllers for terminal equipment:
1. For equipment located in the conditioned space, controllers shall be mounted inside the unit enclosure. Where sufficient mounting space is not available inside the unit enclosure, a control panel shall be installed above the drop ceiling, inside the room, as close to the room space sensor as possible. Coordinate with UCB to clarify acceptable mounting locations.
2. For equipment located above the drop ceiling, controllers shall be unit mounted. (Notify UCB if 36” clearance in front of control panel has not or cannot be provided.) Provide adhesive backed ceiling labels, affixed to ceiling grid below all ceiling concealed controllers, affix to ceiling panel access door for solid ceilings.
F. Laminated control drawings, including system control schematics, sequences of operation and panel termination drawings, shall be provided in panels for major pieces of equipment. Terminal unit drawings shall be located in the central plant equipment panel or mechanical room panel.

3.04 SURGE PROTECTION
A. The Contractor shall furnish and install any power supply surge protection, filters, etc. as necessary for proper operation and protection of all BCs, AAC/ASCS operator interfaces, printers, routers, gateways and other hardware and interface devices. All equipment shall be capable of
handling voltage variations 10% above or below measured nominal value, with no affect on hardware, software, communications, and data storage.

3.05 CONTROL POWER SOURCE AND SUPPLY

A. Section 23 0900 Contractor shall extend all power source wiring required for operation of all equipment and devices provided under Sections 23 0900 through 23 0905 and Sequences of Operation.

B. General requirements for obtaining power include the following:
   1. All control panels shall be served by dedicated power circuits. BC control panels shall additionally be provided with external UPS power supplies to meet the requirements for BC power failure operation in Section 23 0904. Control panel shall be labeled with electrical panel & circuit source.
   2. Where a controller controls multiple systems on varying levels of power reliability (normal, emergency, and/or interruptible), the controller shall be powered by the highest level of reliability served.
   3. Standalone Functionality: Refer to Section 23 0903.
   4. Where control equipment is located inside a new equipment enclosure, coordinate with the equipment manufacturer and feed the control with the same source as the equipment. If the equipment’s control transformer is large enough and of the correct voltage to supply the controls it may be used. If the equipment’s control transformer is not large enough or of the correct voltage to supply the controls provide separate transformer.

3.06 BAS START UP, COMMISSIONING AND TRAINING

A. Refer to Section 23 0801 – BAS Commissioning

3.07 SEQUENCE OF OPERATION

A. Refer to Section 23 0993 - Sequences of Operation

END OF SECTION 23 0900
PART 1 GENERAL

1.01 SECTION INCLUDES:
   A. Building Controller (BC)
   B. Advance Application Specific Controller (AAC)
   C. Application Specific Controller (ASC)

1.02 RELATED DOCUMENTS:
   A. Section 23 05 00 - Basic Mechanical Requirements
   B. Section 23 0900 - Building Automation System (BAS) General
   C. Section 23 0913 – BAS Basic Materials, Interface Devices, and Sensors
   D. Section 23 0902 - BAS Operator Interfaces
   E. Section 23 0904 - BAS Communication Devices
   F. Section 23 0905 - BAS Software and Programming
   G. Section 23 0993 - Sequences of Operation
   H. Section 23 0801 - BAS Commissioning

1.03 DESCRIPTION OF WORK:
   A. Furnish and install DDC Control units and/or Smart Devices required to support specified building automation system functions.
   B. Refer to Section 23 0900 for general requirements.

PART 2 PART 2 - PRODUCTS

2.01 STAND-ALONE FUNCTIONALITY
   A. General: These requirements clarify the requirement for stand-alone functionality relative to packaging I/O devices with a controller. Stand-alone functionality is specified with the controller and for each Application Category specified in Part 3. This item refers to acceptable paradigms for associating the points with the processor.
   B. Functional Boundary: Provide controllers so that all points associated with and common to one unit or other complete system/equipment shall reside within a single control unit. The boundaries of a standalone system shall be as dictated in the contract documents. Generally systems specified for the Application Category will dictate the boundary of the standalone control functionality. See related restrictions below. When referring to the controller as pertains to the standalone functionality, reference is specifically made to the processor. One processor shall execute all the related I/O control logic via one operating system that uses a common programming and configuration tool.
   C. The following configurations are considered acceptable with reference to a controller’s standalone functionality:
      1. Points packaged as integral to the controller such that the point configuration is listed as an essential piece of information for ordering the controller (having a unique ordering number).
      2. Controllers with processors and modular back planes that allow plug in point modules as an integral part of the controller.
3. I/O point expander boards, plugged directly into the main controller board to expand the point capacity of the controller.

4. I/O point expansion devices connected to the main controller board via wiring and as such may be remote from the controller and that communicate via a sub LAN protocol. These arrangements to be considered standalone shall have a sub LAN that is dedicated to that controller and include no other controller devices (AACs or ASCs). All wiring to interconnect the I/O expander board shall be:
   a) Contained in the control panel enclosure;
   b) Or run in conduit. Wiring shall only be accessible at the terminations.

D. The following configurations are considered unacceptable with reference to a controller’s standalone functionality:
   1. Multiple controllers enclosed in the same control panel to accomplish the point requirement.

2.02 BUILDING CONTROLLER (BC)

A. General Requirements:
   1. The BC(s) shall provide fully distributed control independent of the operational status of the OWSs and CSS. All necessary calculations required to achieve control shall be executed within the BC independent of any other device. All control strategies performed by the BC(s) shall be both operator definable and modifiable through the Operator Interfaces.
   2. BCs shall perform overall system coordination, accept control programs, perform automated HVAC functions, control peripheral devices and perform all necessary mathematical and logical functions. BCs shall share information with the entire network of BCs and AACs/ASCs for full global control. Each controller shall permit multi-user operation from multiple workstations and portable operator terminals connected either locally or over the Primary Controller LAN. Each unit shall have its own internal RAM, non-volatile memory, microprocessor, battery backup, regulated power supply, power conditioning equipment, ports for connection of operating interface devices, and control enclosure. BCs shall be programmable from an operator workstation, portable operators terminal, or hand held operating device. BC shall contain sufficient memory for all specified global control strategies, user defined reports and trending, communication programs, and central alarming.
   3. BCs shall be connected to a controller network that qualifies as a Primary Controlling LAN.
   4. All BCs shall be protected from any memory loss due to a loss of power by one or a combination of the following:
      a) Volatile RAM shall have a battery backup using a lithium battery with a rated service life of fifty (50) hours, and a rated shelf life of at least five years. Self-diagnostic routine shall report an alarm for a low battery condition.
      b) EEPROM, EPROM, or NOVROM non-volatile memory
   5. In addition BCs may provide intelligent, standalone control of HVAC functions. Each BC may be capable of standalone direct digital operation utilizing its own processor, non-volatile memory, input/output, wiring terminal strips, A/D converters, real-time clock/calendar and voltage transient and lightning protection devices. Refer to standalone functionality specified above.
   6. The BC may provide for point mix flexibility and expandability. This requirement may be met via either a family of expander boards, modular input/output configuration, or a combination thereof. Refer to stand alone functionality specified above.
   7. All BC point data, algorithms and application software shall be modifiable from the Operator Workstation.
   8. Each BC shall execute application programs, calculations, and commands via a microprocessor resident in the BC. The database and all application programs for each BC
shall be stored in non-volatile or battery backed volatile memory within the BC and will be able to upload/download to/from the OWS and/or CSS.

9. BC shall provide buffer for holding alarms, messages, trends etc.

10. Each BC shall include self-test diagnostics, which allow the BC to automatically alarm any malfunctions, or alarm conditions that exceed desired parameters as determined by programming input.

11. Each BC shall contain software to perform full DDC/PID control loops.

12. For systems requiring end-of-line resistors those resistors shall be located in the BC.

13. Input-Output Processing
   a) Digital Outputs (DO): Outputs shall be rated for a minimum 24 Vac or Vdc, 1 amp maximum current. Each shall be configurable as normally open or normally closed. Each output shall have an LED to indicate the operating mode of the output and [a manual hand off or auto switch to allow for override]. [If these HOA switches are not provided on the main board they shall be provided via isolation relays within the control enclosure.] Each DO shall be discrete outputs from the BC’s board (multiplexing to a separate manufacturer’s board is unacceptable). Provide suppression to limit transients to acceptable levels.
   b) Analog Inputs (AI): AI shall be 0-5 Vdc, 0-10 Vdc, and 0-20 mA. Provide signal conditioning, and zero and span calibration for each input. Each input shall be a discrete input to the BC’s board (multiplexing to a separate manufacturers board is unacceptable unless specifically indicated otherwise). A/D converters shall have a minimum resolution of 12 bits.
   c) Digital Inputs (DI): Monitor dry contact closures. Accept pulsed inputs of at least one per second. Source voltage for sensing shall be supplied by the BC and shall be isolated from the main board.
   d) Universal Inputs (UI-AI or DI): To serve as either AI or DI as specified above.
   e) Electronic Analog Outputs (AO): Voltage mode: 0-5 Vdc and 0-10 Vdc; Current mode: 4-20 mA. Provide zero and span calibration and circuit protection. Pulse Width Modulated (PWM) analog via a DO [and transducer] is acceptable only with University approval (Generally these will not be allowed on loops with a short time constant such as discharge temperature loops, economizer loops, pressure control loops and the like. They are generally acceptable for standard room temperature control loops.). Where these are allowed, transducer/actuator shall be programmable for normally open, normally closed, or hold last position and shall allow adjustable timing. Each DO shall be discrete outputs from the BC’s board (multiplexing to a separate manufacturers board is unacceptable). D/A converters shall have a minimum resolution of 10 bits.
   f) Pulsed Inputs: Capable of counting up to 8 pulses per second with buffer to accumulate pulse count. Pulses shall be counted at all times.

14. A communication port for operator interface through a terminal shall be provided in each BC. It shall be possible to perform all program and database back-up, system monitoring, control functions, and BC diagnostics through this port. Standalone BC panels shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers, or workstations.

15. Each BC shall be equipped with loop tuning algorithm for precise proportional, integral, derivative (PID) control. Loop tuning tools provided with the Operator Workstation software is acceptable. In any case, tools to support loop tuning must be provided such that P, I, and D gains are automatically calculated.

16. All analog output points shall have a selectable failure setpoint. The BC shall be capable of maintaining this failure setpoint in the event of a system malfunction, which causes loss of BC control, or loss of output signal, as long as power is available at the BC. The failure setpoint shall be selectable on a per point basis.

17. Slope intercepts and gain adjustments shall be available on a per-point basis.
18. BC Power Loss:
   a) Upon a loss of power to any BC, the other units on the primary controlling network shall not in any way be affected.
   b) Upon a loss of power to any BC, the battery backup shall ensure that the energy management control software, the Direct Digital Control software, the database parameters, and all other programs and data stored in the RAM are retained for a minimum of fifty (50) hours. *An alarm diagnostic message shall indicate that the BC is under battery power.*
   c) Upon restoration of power within the specified battery backup period, the BC shall resume full operation without operator intervention. The BC shall automatically reset its clock such that proper operation of any time dependent function is possible without manual reset of the clock. All monitored functions shall be updated.
   d) Should the duration of a loss of power exceed the specified battery back-up period or BC panel memory be lost for any reason, the panel shall automatically report the condition (upon resumption of power) and be capable of receiving a download via the network, and connected computer. In addition, the University shall be able to upload the most current versions of all energy management control programs, Direct Digital Control programs, database parameters, and all other data and programs in the memory of each BC to the operator workstation via the local area network, or via the telephone line dial-up modem where applicable, or to the laptop PC via the local RS-232C port.

19. BC Failure:
   a) Building Controller LAN Data Transmission Failure: BC shall continue to operate in stand-alone mode. BC shall store loss of communication alarm along with the time of the event. All control functions shall continue with the global values programmable to either last value or a specified value. Peer BCs shall recognize the loss, report alarm and reconfigure the LAN.
   b) BC Hardware Failure: BC shall cease operation and terminate communication with other devices. All outputs shall go to their specified fail position.

20. Each BC shall be equipped with firmware resident self-diagnostics for sensors and be capable of assessing an open or shorted sensor circuit and taking an appropriate control action (close valve, damper, etc.).

21. BCs may include LAN communications interface functions for controlling secondary controlling LANs. Refer to Section 23 0904 - BAS System Communications Devices for requirements if this function is packaged with the BC.

22. BCs shall be mounted on equipment, in packaged equipment enclosures, or locking wall mounted in a NEMA 1 enclosure, as specified elsewhere.

B. BACnet Building Controller Requirements:
   1. The BC(s) shall support all BIBBs defined in the BACnet Building Controller (B-BC) device profile as defined in the BACnet standard.
   2. BCs shall communicate over the BACnet Building Controller LAN.
   3. Each BC shall be connected to the BACnet Building Controller LAN communicating to/from other BCs.

2.03 ADVANCED APPLICATION SPECIFIC CONTROLLER (AAC) AND APPLICATION SPECIFIC CONTROLLER (ASC)

A. General Requirements:
   1. AACs and ASCs shall provide intelligent, standalone control of HVAC equipment. Each unit shall have its own internal RAM, non-volatile memory and will continue to operate all local control functions in the event of a loss of communications on the ASC LAN or sub-LAN. Refer to standalone requirements by application specified in Part 3 of this section. In
addition, it shall be able to share information with every other BC and AAC /ASC on the entire network.

2. Each AAC and ASC shall include self-test diagnostics that allow the AAC /ASC to automatically relay to the BC, LAN Interface Device or workstation, any malfunctions or abnormal conditions within the AAC /ASC or alarm conditions of inputs that exceed desired parameters as determined by programming input.

3. AACs and ASCs shall include sufficient memory to perform the specific control functions required for its application and to communicate with other devices.

4. Each AAC and ASC must be capable of stand-alone direct digital operation utilizing its own processor, non-volatile memory, input/output, minimum 8 bit A to D conversion, voltage transient and lightning protection devices. All volatile memory shall have a battery backup of at least fifty- (50) hrs with a battery life of five years.

5. All point data; algorithms and application software within an AAC /ASC shall be modifiable from the Operator Workstation.

6. AAC and ASC Input-Output Processing
   a) **Digital Outputs (DO):** Outputs shall be rated for a minimum 24 VAC or VDC, 1 amp maximum current. Each shall be configurable as normally open or normally closed. Each output shall have an LED to indicate the operating mode of the output and a manual hand off or auto switch to allow for override. [If these HOA switches are not provided on the main board they shall be provided via isolation relays within the control enclosure.] Each DO shall be discrete outputs from the AAC/ASC’s board (multiplexing to a separate manufacturer’s board is unacceptable). Provide suppression to limit transients to acceptable levels.
   b) **Analog Inputs (AI):** AI shall be 0-5 Vdc, 0-10Vdc, 0-20Vdc, and 0-20 mA. Provide signal conditioning, and zero and span calibration for each input. Each input shall be a discrete input to the BC’s board (multiplexing to a separate manufacturers board is unacceptable unless specifically indicated otherwise). A/D converters shall have a minimum resolution of 8-10 bits depending on application.
   c) **Digital Inputs (DI):** Monitor dry contact closures. Accept pulsed inputs of at least one per second. Source voltage for sensing shall be supplied by the BC and shall be isolated from the main board. Software multiplexing of an AI and resistors may only be done in non-critical applications and only with prior approval of Architect/Engineer.
   d) **Universal Inputs (UI-AI or DI):** To serve as either AI or DI as specified above.
   e) **Electronic Analog Outputs (AO) as required by application:** voltage mode, 0-5VDC and 0-10VDC; current mode (4-20 mA). Provide zero and span calibration and circuit protection. D/A converters shall have a minimum resolution of 8 bits.

B. **BACnet AAC(s) and ASC(s) Requirements:**
   1. The AAC(s) and ASC(s) shall support all BIBBs defined in the BACnet Building Controller (B-AAC and B-ASC) device profile as defined in the BACnet standard.
   2. AAC(s) and ASC(s) shall communicate over the BACnet Building Controller LAN or the ASC LAN or sub-LAN.
   3. Each BC shall be connected to the BACnet Building Controller LAN communicating to/from other BCs.

C. **Terminal Box Controllers:**
   1. Terminal box controllers controlling damper positions to maintain a quantity of supply or exhaust air serving a space shall have an automatically initiated function that resets the volume regulator damper to the fully closed position on a scheduled basis. The controllers shall initially be set up to perform this function once every 24 hours. The purpose of this required function is to reset and synchronize the actual damper position with the calculated damper position and to assure the damper will completely close when commanded. The software shall select scheduled boxes randomly and shall not allow more than 5% of the total
quantity of controllers in a building to perform this function at the same time. When possible
the controllers shall perform this function when the supply or exhaust air system is not
operating or is unoccupied.

PART 3 EXECUTION

3.01 INSPECTION:
A. Examine areas and conditions under which control systems are to be installed. Do not proceed
with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.02 INSTALLATION OF CONTROL SYSTEMS:
A. General: Install systems and materials in accordance with manufacturer's instructions,
specifications roughing-in drawings and details shown on drawings. Contractor shall install all
controllers in accordance with manufacturer’s installation procedures and practices.

3.03 HARDWARE APPLICATION REQUIREMENTS
A. General: The functional intent of this specification is to allow cost effective application of
manufacturers standard products while maintain the integrity and reliability of the control
functions. A Building Controller as specified above is generally fully featured and customizable
whereas the AAC/ASC refers to a more cost-effective unit designed for lower-end applications.
Specific requirements indicated below are required for the respective application. Manufacturer
may apply the most cost-effective unit that meets the requirement of that application.
B. Standalone Capability: Each Control Unit shall be capable of performing the required sequence
of operation for the associated equipment. All physical point data and calculated values required
to accomplish the sequence of operation shall originate within the associated CU with only the
exceptions enumerated below. Refer to Item 2.01 above for physical limitations of standalone
functionality. Listed below are functional point data and calculated values that shall be allowed to
be obtained from or stored by other CUs or SDs via LAN.
C. Where associated control functions involve functions from different categories identified below,
the requirements for the most restrictive category shall be met.
D. Application Category 0 (Distributed monitoring)
1. Applications in this category include the following:
   a) Monitoring of variables that are not used in a control loop, sequence logic, or safety.
2. Points on BCs, AACs, and ASCs may be used in these applications as well as SDs and/or
general-purpose I/O modules.
3. Where these points are trended, contractor shall verify and document that the network
   bandwidth is acceptable for such trends and is still capable of acceptable and timely control
   function.

E. Application Category 1 (Application Specific Controller):
1. Applications in this category include the following:
   a) Fan Coil Units
   b) Airflow Control Boxes (VAV and Constant Volume Terminal Units)
   c) Misc. Heaters
   d) Unitary equipment <15 tons (Package Terminal AC Units, Package Terminal Heat
      Pumps, Split-System AC Units, Split-System Heat Pumps, Water-Source Heat Pumps)
   e) Induction Units
   f) Variable Speed Drive (VSD) controllers not requiring safety shutdowns of the
      controlled device.
2. ASCs may be used in these applications.

3. **Standalone Capability**: Provide capability to execute control functions for the application for a given setpoint or mode, which shall generally be occupied mode control. Only the following data (as applicable) may be acquired from other controllers via LANs. In the event of a loss of communications with any other controller, or any fault in any system hardware that interrupts the acquisition of any of these values, the ASC shall use the last value obtained before the fault occurred. If such fault has not been corrected after the specified default delay time, specified default value(s) shall then be substituted until such fault has been corrected.

<table>
<thead>
<tr>
<th>Physical/Virtual Point</th>
<th>Default Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scheduling Period</td>
<td>Normal</td>
</tr>
<tr>
<td>Morning Warm-Up</td>
<td>Off (cold discharge air)</td>
</tr>
<tr>
<td>Load Shed</td>
<td>Off (no shedding)</td>
</tr>
<tr>
<td>Summer/Winter</td>
<td>Winter</td>
</tr>
</tbody>
</table>

4. **Mounting**: 
   a) ASCs that control equipment located above accessible ceilings shall be mounted on the equipment in an accessible enclosure (36” clearance required) and shall be rated for plenum use.
   b) ASCs that control equipment mounted in a mechanical room may either be mounted in, on the equipment, or on the wall of the mechanical room at an adjacent, accessible location.
   c) ASCs that control equipment mounted outside or in occupied spaces shall either be located in the unit or in a proximate mechanical space.
   d) Section 23 0913 contractor may furnish ASCs to the terminal unit manufacturer for factory mounting.

5. **Programmability**: Operator shall be able to modify all setpoints (temperature and airflow), scheduling parameters associated with the unit, tuning and set up parameters, interstage timing parameters, and mode settings. Application-specific block control algorithms may be used to meet the sequence of operations. The ability to customize the control algorithm is not required unless specifically indicated otherwise.

6. **Network Restrictions**: Limit the number of nodes on the network to the maximum recommended by the manufacturer.

F. **Application Category 2** (General Purpose Terminal Controller)

1. Applications in this category include the following:
   a) Unitary Equipment >= 15 tons (Air Conditioners, Heat Pumps, Packaged Heating/Cooling Units, and the like)
   b) Small, Constant Volume Single Zone Air Handling Units
   c) Constant Volume Pump Start/Stop
   d) Misc. Equipment (Exhaust Fan) Start/Stop
   e) Misc. Monitoring (not directly associated with a control sequence and where trending is not critical)
   f) Steam Converter Control
2. BCs may be used in these applications.
3. ASC’s may be used in these applications provided the ASC meets all requirements specified below. This category requires a general-purpose ASC to which application-specific control algorithms can be attached.
4. **Standalone Capability**: Only the following data (as applicable) may be acquired from other ASCs via LANs. In the event of a loss of communications with any other ASCs, or any fault in any system hardware that interrupts the acquisition of any of these values, the AAC/ASC shall use the last value obtained before the fault occurred.
5. **Mounting:**
   a) ASCs that control equipment located above accessible (36” clearance required) ceilings shall be mounted on the equipment and shall be rated for plenum use.
   b) ASCs that control equipment located in occupied spaces or outside shall either be mounted within the equipment enclosure (responsibility for physical fit remains with the contractor) or in a near by mechanical/utility room in which case it shall be enclosed in a NEMA 1, locking enclosure.

6. **Programmability:** Operator shall be able to modify all setpoints (temperature and airflow), scheduling parameters associated with the unit, tuning and set up parameters, interstage timing parameters, and mode settings. Operator shall be able to address and configure spare inputs for monitoring. Operator shall be able to address and configure spare outputs for simple single loop control actions or event initiated actions. Application-specific block control algorithms may be used to meet the sequence of operations.

7. **Network Restrictions:** Limit the number of nodes servicing any one of these applications on the AAC/ASC LAN to 32.

G. **Application Category 3 (Advanced Application Controller)**

   1. Applications in this category include the following:
      a) Large Constant Volume Air Handlers
      b) VAV Air Handlers (generally >5,000 and <10,000cfm)
      c) Self Contained VAV Units

   2. BCs may be used in these applications.

   3. AAC’s may be used in these applications provided:
      a) The AAC’s meets all requirements specified below.
      b) All control functions and physical I/O associated with a given unit resides in one AAC.
      c) Input A/D is 10-bit. Exception: 8-bit input A/D can be used when matched with high accuracy sensors, the range of which meets the resolution requirements specified for the applicable sensor in Section 23 0900.
      d) Pulsed inputs required for the application can be monitored and accumulated effectively.

   4. **Standalone Capability:** Only the following data (as applicable) may be acquired from other AACs via LANs. In the event of a loss of communications with any other AACs, or any fault in any system hardware that interrupts the acquisition of any of these values, the AAC shall use the last value obtained before the fault occurred.

   5. **Mounting:**
      a) AACs that control equipment located above accessible (36” clearance required) ceilings shall be mounted on the equipment and shall be rated for plenum use.
      b) AACs that control equipment located in occupied spaces or outside shall either be mounted within the equipment enclosure (responsibility for physical fit remains with the contractor) or in a near by mechanical/utility room in which case it shall be enclosed in a NEMA 1, locking enclosure.

   6. **Programmability:** Operator shall be able to modify all setpoints (temperature and airflow), scheduling parameters associated with the unit, tuning and set up parameters, interstage timing parameters, and mode settings. Operator shall be able to address and configure spare inputs for monitoring. Operator shall be able to program custom DDC control algorithms and specify trending parameters, which will be retained in memory in the event of a loss of communications. Application-specific block control algorithms may be used provided they meet the sequence of operations. The control algorithms shall be completely customizable.

   7. **Network Restrictions:** Each LAN which participates in the transfer of data between the CU and the local operator workstation shall be subject to the following criteria:
a) Limit the number of nodes servicing any one of these applications on the AAC/ASC LAN to 16.

b) The building controller LAN shall be subject only to manufacturer’s published LAN limitations.

H. Application Category 4

1. Applications in this category include the following:
   a) Central Cooling Plant
   b) Central Heating Plant
   c) Cooling Towers
   d) Sequenced or Variable Speed Pump Control
   e) Local Chiller Control (unit specific)
   f) Local Free Cooling Heat Exchanger Control
   g) Air Handlers over 10,000 cfm or serving critical areas

2. BCs shall be used in these applications.

3.04 NETWORK BANDWIDTH MANAGEMENT

A. This section is designed to address the MS/TP networks within the DDC systems. Information passed within the MS/TP network will greatly affect the overall performance of the building systems. Scan times from the first controller to the last controller within the building network that exceed 2 seconds are not acceptable. If scan times of 2 seconds or less cannot be achieved, contact UCB.

B. Once the network is properly configured the contractor shall provide a network bandwidth analysis of the controller network. The analysis shall document network bandwidth utilization does not exceed the requirements stated above for a continuous one hour period.

3.05 CONTROL UNIT REQUIREMENTS

A. Refer to Section 23 0900 for requirements pertaining to control unit quantity and location.

END OF SECTION 23 0903
SECTION 23 0904
BAS COMMUNICATION DEVICES

PART 1 GENERAL

1.01 SECTION INCLUDES
   A. Network Connection
   B. Local Supervisory LAN Gateways/Routers
   C. Chiller Controls Interface Device (CID)

1.02 RELATED DOCUMENTS:
   A. Drawings and general provisions of Contract, including General and Supplementary Conditions
      and Division-1 Specification sections, apply to work of this section.
   B. Section 23 05 00 - Basic Mechanical Requirements
   C. Section 23 0900 - Building Automation System (BAS) General
   D. Section 23 0913 – BAS Basic Materials, Interface Devices, and Sensors
   E. Section 23 0902 - BAS Operator Interfaces
   F. Section 23 0903 - BAS Field Panels
   G. Section 23 0905 - BAS Software and Programming
   H. Section 23 0993 - Sequences of Operation
   I. Section 23 0801 - BAS Commissioning

1.03 DESCRIPTION OF WORK
   A. Contractor shall provide all interface devices and software to provide an integrated system
      connecting BCs, AACs, ASCs and Gateways to the University network.

PART 2 PRODUCTS

2.01 NETWORK CONNECTION
   A. **UCB Private VLAN**: Internet-based network connecting the BAS across multiple facilities with
      a central data warehouse and server, accessible via standard web-browser. This is an existing
      infrastructure and Contractor is not required to configure any components of this VLAN.
      Contractor is however required to provide BACnet Objects and services at the Local Supervisory
      LAN via BACnet over IP.

2.02 LOCAL SUPERVISORY LAN GATEWAYS/ROUTERS
   A. The Supervisory Gateway shall be a microprocessor-based communications device that acts as a
      gateway/router between the Supervisory LAN CSSs or OWS and the Primary LAN.
   B. The Gateway shall perform information translation between the Primary LAN and the Local
      Supervisory LAN, which is 100 Mbps Ethernet TCP/IP and shall preferably use BACnet over IP.
   C. The gateway shall contain its own microprocessor, RAM, battery, real-time clock, communication
      ports, and power supply as specified for a BC in Section 23 0903. Each gateway/router shall be
      mounted in a lockable enclosure unless it is a PC that also serves as an OWS.
   D. The gateway/router shall allow centralized overall system supervision, operator interface,
      management report generation, alarm annunciation, acquisition of trend data, and communication
with control units. It shall allow system operators to perform the following functions from the CSS, OWSs, and POTs:

1. Configure systems.
2. Monitor and supervise control of all points.
3. Change control setpoints.
4. Override input values.
5. Override output values
6. Enter programmed start/stop time schedules.
7. View and acknowledge alarms and messages.
8. Receive, store and display trend logs and management reports.
9. Upload/Download programs, databases, etc. as specified.

E. Upon loss of power to the Gateway, the battery shall provide for minimum 100 hour backup of all programs and data in RAM. The battery shall be sealed and self-charging.

F. The Gateway shall be transparent to control functions and shall not be required to control information routing on the Primary LAN.

2.03 CHILLER CONTROLS INTERFACE DEVICE (CID)

A. The CID shall be a microprocessor-based communications device that acts as a gateway between the control protocol and the applicable chiller controller protocol.

B. The CID shall contain its own microprocessor, RAM, battery, communication ports and, power supply.

C. Each CID shall support full bi-directional communications translation as more fully specified in Section 230905.

D. The following points shall be mapped as a minimum:
   1. CHW Supply and Return Temperatures
   2. CW Supply and Return Temperatures
   3. Power Consumption (kW)
   4. Percent of Power Consumption (compared to maximum)
   5. Bearing Temperature
   6. Suction and Head Pressures
   7. Suction and Head Temperatures
   8. All available alarms; common alarm as minimum
   9. Chiller Status
   10. Enable/Disable
   11. Current Limit Percent
   12. CHW Setpoint and Setpoint Reset

E. Notify the Engineer/Owner prior to submittals if any of the above points cannot be shared by the chiller.

PART 3 EXECUTION

3.01 INSPECTION:

A. Examine areas and conditions under which control systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.
3.02 INSTALLATION OF CONTROL SYSTEMS:

A. General: Install systems and materials in accordance with manufacturer's instructions, roughing-in drawings and details shown on drawings.

B. Contractor shall provide all interface devices and software to provide an integrated system.

C. Contractor shall closely coordinate with the University, or designated representative, to establish IP addresses and communications to assure proper operation of the building control system on the University VLAN.

END OF SECTION 23 0904
PART 1. GENERAL

1.01 SECTION INCLUDES

A. System Software
B. Programming Description
C. Control Algorithms
D. Energy Management Applications
E. Password Protection
F. Alarm Reporting
G. Trending
H. Data Acquisition and Storage
I. Dynamic Color Graphics

1.02 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.
B. Section 23 05 00 - Basic Mechanical Requirements
C. Section 23 0900 - Building Automation System (BAS) General
D. Section 23 0913 - BAS Basic Materials, Interface Devices, and Sensors
E. Section 23 0902 - BAS Operator Interfaces
F. Section 23 0903 - BAS Field Panels
G. Section 23 0904 - BAS Communication Devices
H. Section 23 0993 - Sequences of Operation
I. Section 23 0801 - BAS Commissioning

1.03 DESCRIPTION OF WORK:

A. Fully configure systems and furnish and install all software, programming and dynamic color graphics for a complete and fully functioning system as specified.
B. Refer to Section 23 0900 - Building Automation System (BAS) for general requirements
C. Refer to 230993 - Sequence of Operation for general sequence of operation requirements.

1.04 LICENSING

A. Include licensing for all software packages at all required workstations.
B. All software used for the operator interface, programming environment, networking, database management and any other software used by the Contractor to install the system or needed to operate the system to its full capabilities shall be licensed and provided to the University.
C. All software should be available on all Operator Workstations or CSSs provided, and on all Portable Operator Terminals. Hardware and software keys to provide all rights shall be installed on all workstations. At least 2 sets of CDs shall be provided with backup software for all software provided, so that the University may reinstall any software as necessary. Include all licensing for workstation operating systems, and all required third-party software licenses.
D. Provide licensing and original software copies for each OWS or CSS.
E. Provide licensing and original software copies for each remote graphic workstation. Licenses for remote graphic workstations shall allow for access to any site and shall not be restricted to accessing only the LANs included in this project.
F. Upgrade all software packages to the release (version) in effect at the end of the Warranty Period.
G. Refer to Section 23 0900 - Building Automation System (BAS) General for further requirements.

PART 2. PRODUCTS

2.01 SYSTEM SOFTWARE-GENERAL
A. Functionality and Completeness: The Contractor shall furnish and install all software and programming necessary to provide a complete and functioning system as specified. The Contractor shall include all software and programming not specifically itemized in these Specifications, which is necessary to implement, maintain, operate, and diagnose the system in compliance with these Specifications.
B. Configuration: The software shall support the system as a distributed processing network configuration.

2.02 CONTROLLER SOFTWARE
A. BC Software Residency: Each BC as defined below shall be capable of control and monitoring of all points physically connected to it. All software including the following shall reside and execute at the BC:
   1. Real-Time Operating System software
   2. Real-Time Clock/Calendar and network time synchronization
   3. BC diagnostic software
   4. LAN Communication software/firmware
   5. Direct Digital Control software
   6. Alarm Processing and Buffering software
   7. Energy Management software
   8. Data Trending, Reporting, and Buffering software
   9. I/O (physical and virtual) database
   10. Remote Communication software
B. AAC/ASC Software Residency: Each AAC/ASC as defined below shall be capable of control and monitoring of all points physically connected to it. As a minimum, software including the following shall reside and execute at the AAC/ASC. Other software to support other required functions of the AAC/ASC may reside at the BC or LAN interface device (specified in Section 23 0904 with the restrictions/exceptions per application provided in Section 23 0903:
   1. Real-Time Operating System software
   2. AAC/ASC diagnostic software
   3. LAN Communication software
   4. Control software applicable to the unit it serves that will support a single mode of operation
   5. I/O (physical and virtual) database to support one mode of operation
C. Stand Alone Capability: BC shall continue to perform all functions independent of a failure in other BC/AAC/ASC or other communication links to other BCs/AACs/ASCs. Trends and runtime totalization shall be retained in memory. Runtime totalization shall be available on all digital input points that monitor electric motor status. Refer also to Section 23 0903 for other aspects of stand alone functionality.
D. **Operating System**: Controllers shall include a real-time operating system resident in ROM. This software shall execute independently from any other devices in the system. It shall support all specified functions. It shall provide a command prioritization scheme to allow functional override of control functions. Refer also to Section 23 0903 for other aspects of the controllers operating system.

E. **Network Communications**: Each controller shall include software/firmware that supports the networking of CUs on a common communications trunk that forms the respective LAN. Network support shall include the following:
   1. Building Controller/Primary LAN shall be a high-speed network designed and optimized for control system communication. If a Primary LAN communications trunk is severed, BCs shall reconfigure into two separate LANs and continue operations without interruption or Operator intervention.
   2. Controller communication software shall include error detection, correction, and retransmission to ensure data integrity.
   3. Operator/System communication software shall facilitate communications between other BCs, all subordinate AACS/ASCs, Gateways and LAN Interface Devices or Operator Workstations. Software shall allow point interrogation, adjustment, addition/deletion, and programming while the controller is on line and functioning without disruption to unaffected points. The software architecture shall allow networked controllers to share selected physical and virtual point information throughout the entire system.

F. **Diagnostic Software**: Controller software shall include diagnostic software that checks memory and communications and reports any malfunctions

G. **Alarm/Messaging Software**: Controller software shall support alarm/message processing and buffering software as more fully specified below.

H. **Application Programs**: CUs shall support and execute application programs as more fully specified below:
   1. All Direct Digital Control software, Energy Management Control software, and functional block application programming software templates shall be provided in a ‘ready-to-use’ state, and shall not require (but shall allow) Owner programming.

I. **Security**: Controller software shall support multiple level password access restriction as more fully specified below.

J. **Direct Digital Control**: Controller shall support application of Direct Digital Control Logic. All logic modules shall be provided pre-programmed with written documentation to support their application. Provide the following logic modules as a minimum:
   1. Proportional-Integral-Derivative (PID) control with analog, PWM and floating output
   2. Two Position control (Hi or Low crossing with deadband)
   3. Single-Pole Double-Throw relay
   4. Delay Timer (delay-on-make, delay-on-break, and interval)
   5. Hi/Low Selection
   6. Reset or Scaling Module
   7. Logical Operators (AND, OR, NOT, XOR)

K. **Psychrometric Parameters**: Controller software shall provide preprogrammed functions to calculate and present psychrometric parameters (given temperature and relative humidity) including the following as a minimum: Enthalpy, Wet Bulb Temperature.

L. **Updating/Storing Application Data**: Site-specific programming residing in volatile memory shall be uploadable/downloadable from an OWS or CSS connected locally, to the Primary LAN, to the Local Supervisory LAN and remotely via the internet. Initiation of an upload or download shall include the following methods; Manually and Automatically upon detection of a loss or change.
M. **Restart**: System software shall provide for orderly shutdown upon loss of power and automatic restart upon power restoration. Volatile memory shall be retained; outputs shall go to programmed fail (open, closed, or last) position. Equipment restart shall include a user definable time delay on each piece of equipment to stagger the restart. Loss of power shall be alarmed at operator interface indicating date and time.

N. **Time Synchronization**: Operators shall be able to set the time and date in any device on the network that supports time-of-day functionality. The operator shall be able to select to set the time and date for an individual device, devices on a single network, or all devices simultaneously. Automatic time synchronization shall be provided.

O. **Misc. Calculations**: System software shall automate calculation of psychometric functions, calendar functions, kWh/kW, and flow determination and totalization from pulsed or analog inputs, curve-fitting, look-up table, input/output scaling, time averaging of inputs and A/D conversion coefficients.

2.03 **APPLICATION PROGRAMMING DESCRIPTION**

A. The application software shall be user programmable.

B. This specification generally requires a programming convention that is logical, easy to learn, use, and diagnose. General approaches to application programming shall be provided by one, or a combination, of the following conventions:

   1. **Point Definition**: provide templates customized for point type, to support input of individual point information. Use standard BACnet Objects as applicable.

   2. **Graphical Block Programming**: Manipulation of graphic icon ‘blocks’, each of which represents a subroutine, in a functional/logical manner forming a control logic diagram. Blocks shall allow entry of adjustable settings and parameters via pop-up windows. Provide a utility that shall allow the graphic logic diagrams to be directly compiled into application programs. Logic diagrams shall be viewable either off-line, or on-line with real-time block output values.

C. Provide a means for testing and/or debugging the control programs both off-line and on-line.

2.04 **ENERGY MANAGEMENT APPLICATIONS**

A. System shall have the ability to perform all of the following energy management routines via preprogrammed function blocks or template programs. As a minimum provide the following whether or not required in the software:

   1. Time-of-Day Scheduling
   2. Calendar-Based Scheduling
   3. Holiday Scheduling
   4. Temporary Schedule Overrides
   5. Optimal Start/Optimal Stop-based on space temperature offset, outdoor air temperature, and building heating and cooling capacitance factors as a minimum
   6. Night Setback and Morning Recovery Control, with ventilation only during occupancy
   7. Economizer Control (enthalpy or dry-bulb)
   8. Economizer Control (hydronic)
   9. Peak Demand Limiting / Load Shedding
   10. Lighting/Occupancy Control
   11. Dead Band Control

B. All programs shall be executed automatically without the need for operator intervention, and shall be flexible enough to allow operator customization. Programs shall be applied to building equipment as described in Section 23 0993 - Sequence of Operation’.
2.05 PASSWORD PROTECTION

A. Multiple-level password access protection shall be provided to allow the University’s authorized BAS Administrator to limit workstation control, display and database manipulation capabilities as they deem appropriate for each user, based upon an assigned user name with a unique password.

B. All passwords for the system shall be provided to the University including administrator, dealer, or factory level passwords for the systems provided under this project.

C. Passwords shall restrict access to all Control Units.

D. Each user name shall be assigned to a discrete access level. A minimum of five levels of access shall be supported. Alternately, a comprehensive list of accessibility/functionality items shall be provided, to be enabled or disabled for each user.

E. A minimum of 50 user names shall be supported and programmed per the University’s direction.

F. Operators shall be able to perform only those commands available for the access level assigned to their user name.

G. User-definable, automatic log-off timers of from 1 to 60 minutes shall be provided to prevent operators from inadvertently leaving interface device software on-line.

2.06 ALARM AND EVENT MANAGEMENT REPORTING

A. Alarm management shall be provided to monitor, buffer, and direct alarms and messages to operator devices and memory files. The CSS shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic, and prevent alarms from being lost. At no time shall a BC’s ability to report alarms be affected by either operator activity at an Operator Workstation or local handheld device, or by communications with other panels on the network.

1. **Alarm Descriptor**: Each alarm or point change shall include that point’s English language description, and the time and date of occurrence. In addition to the alarm’s descriptor and the time and date, the user shall be able to print, display and store an alarm message to more fully describe the alarm condition or direct operator response.

2. **Alarm Prioritization**: The software shall allow users to define the handling and routing of each alarm by their assignment to discrete priority levels. A minimum of five priority levels shall be provided. For each priority level, users shall have the ability to enable or disable an audible tone whenever an alarm is reported and whenever an alarm returns to normal condition. Users shall have the ability to manually inhibit alarm reporting for each individual alarm and for each priority level. Contractor shall coordinate with the University on establishing alarm priority definitions. Alarm Level 1 Life Safety (i.e. smoke detector), Level 2 Critical (i.e. controller failure), Level 3 Abnormal (i.e. out-of-range temperature), Level 4 Energy Waste (i.e. fighting valves), Level 5 Maintenance Message (i.e. runtime monitor, filter status).

3. **Alarm Report Routing**: Each alarm priority level shall be associated with a unique user-defined list of operator devices including any combination of local or remote workstations, printers, email accounts, SMS accounts and workstation disk files. All alarms associated with a given priority level shall be routed to all operator devices on the user-defined list associated with that priority level. For each priority level, alarms shall be automatically routed to a default operator device in the event that alarms are unable to be routed to any operator device assigned to the priority level.

4. **Alarm Acknowledgment**: For alarm priority levels that are directed to a workstation screen, an indication of alarm receipt shall be displayed immediately regardless of the application in use at the workstation, and shall remain on the screen until acknowledged by a user having a password that allows alarm acknowledgment. Upon acknowledgment, the complete alarm message string (including date, time, and user name of acknowledging operator) shall be stored in the CSS database.
B. It shall be possible for any operator to receive a summary of all alarms regardless of acknowledgement status; for which a particular recipient is enrolled for notification; based on current event state; based on the particular event algorithm (e.g., change of value, change of state, out of range, and so on); alarm priority; and notification class.

C. **BACnet Alarming Services**: All alarms and events shall be implemented using standard BACnet event detection and notification mechanisms. The workstation shall receive BACnet alarm and event notifications from any gateway or BACnet controller in the system and display them to an operator. The workstation shall also log alarms and events, provide a way for an operator with sufficient privilege to acknowledge alarms, and log acknowledgements of alarms. It shall be possible for an operator to receive, at any time, a summary of all alarms that are currently in effect at any site whether or not they have been acknowledged. Operators shall also be able to view and change alarm limits for any alarm at the appropriate password level.

D. **Alarm Historical Database**: The database shall store all alarms and events object occurrences in an ODBC or an OLE database-compliant relational database. Provide a commercially available ODBC driver or OLE database data provider, which would allow applications to access the data using standard Microsoft Windows Data Services.

### 2.07 TRENDING

A. The software shall display historical data in both a tabular and graphical format. The requirements of this trending shall include the following:

1. Provide trends for all physical points, virtual points and calculated variables.
2. The sample rate and data selection shall be selectable by the operator.
3. The trended value range shall be selectable by the operator.
4. Workstations shall be able to display up to four simultaneous trend graphs with up to four data points per graph.
5. The data points must be exportable from any operator interface in CSV or MS Excel format.

B. **Control Loop Performance Trends**: Controllers incorporating PID control loops shall also provide high resolution sampling in less than five second increments for verification of control loop performance.

C. **Data Buffering and Archiving**: Trend data shall be buffered at the CUs, and uploaded to CSS storage when archival is desired. All archived trends shall be transmitted to the on-site OWS as applicable. Uploads shall occur based upon a user-defined interval, manual command, or automatically when the trend buffers become full.

D. **Time Synchronization**: Provide a time master that is installed and configured to synchronize the clocks of all BACnet devices supporting time synchronization. Synchronization shall be done using Coordinated Universal Time (UTC). All trend sample times shall be able to be synchronized. The frequency of time synchronization message transmission shall be selectable by the operator.

### 2.08 TOTALIZATION

A. The software shall support totalizing analog, digital, and pulsed inputs and be capable of accumulating, storing, and converting these totals to engineering units used in the documents. These values shall generally be accessible to the Operator Interfaces to support management-reporting functions.

B. Totalization of electricity use/demand shall allow application of totals to different rate periods, which shall be user definable.

C. When specified to provide electrical or utility Use/Demand, the Contractor shall obtain from the local utility all information required to obtain meter data, including k factors, conversion constants, and the like.
2.09 SCHEDULING
A. Provide a graphic utility for user-friendly operator interface to adjust equipment-operating schedules.
B. Scheduling feature shall include multiple seven-day master schedules, holiday schedules and override schedules, each with start time and stop time. Master schedules shall be individually editable for each day and holiday.
C. Scheduling feature shall allow for each individual equipment unit to be assigned to one of the master schedules.
D. Timed override feature shall allow an operator to temporarily change the state of scheduled equipment. An override command shall be selectable to apply to an individual unit, all units assigned to a given master schedule, or to all units in a building. Timed override shall terminate at the end of an operator selectable time, or at the end of the scheduled occupied/unoccupied period, whichever comes first. A password level that does not allow assignment of master schedules shall allow a timed override feature.
E. A yearly calendar feature shall allow assignment of holidays, and automatic reset of system real time clocks for transitions between daylight savings time and standard time.

2.10 OVERRIDES
A. BAS shall provide an audit log report of all overrides currently active, historical overrides along with the user who initiated the override.
B. Provide a screen graphic for manual override of the "OFF" for all Scheduled Start/Stop Zones. Provide the necessary software to start any desired zone's equipment by touch screen. The program shall permit operator selection of zones and shall enable all related equipment for that particular zone. The program shall index the selected zone to an "ON" mode in a minimum of one-hour increments for a period of up to six hours in the override condition. Once overridden, the zone equipment shall operate in the occupied mode, including exhaust fan interlocks.
C. Timed override feature shall allow an operator to temporarily change the state of scheduled equipment. An override command shall be selectable to apply to an individual unit, all units assigned to a given master schedule, or to all units in a building. Timed override shall terminate at the end of an operator selectable time, or at the end of the scheduled occupied/unoccupied period, whichever comes first. A password level that does not allow assignment of master schedules shall allow a timed override feature.
D. Provide equipment override programs for all energy recovery units, air handling units, and heating and ventilating units. Program shall allow operator to override ERU, AHU, or HVU “Off” command to enable individual units for operation without overriding Zone command. Duration of override shall be for 3 hours. Intent is to allow ERUs, AHUs, or HVUs to run for maintenance servicing without requiring other equipment in the zone to operate as would be required if the Zone were overridden on.
E. Provide a single point outdoor air damper override. Intent is to allow the BAS operator to command all outdoor air intake dampers controlled by BAS to be closed by a single command.
F. Provide a single point Zones override. Intent is to allow the BAS operator to command all Zones to the unoccupied mode, effectively closing all outdoor air dampers and shutting down exhaust fans.
G. Override shall be possible for analog or time clock values for a given period of time, until a given time or permanently. Overrides may be cleared at the keyboard or through programmable user functions.

2.11 OPERATOR INTERFACE GRAPHIC SOFTWARE
A. Graphic software shall facilitate user-friendly interface to all aspects of the System Software specified above. The intent of this specification is to require a graphic package that provides for
intuitive operation of the systems without extensive training and experience. It shall facilitate logical and simple system interrogation, modification, configuration, and diagnosis.

B. Graphic software shall support multiple simultaneous screens to be displayed and resizable in a ‘Windows’-like environment. All functions excepting text entry functions shall be executable with a mouse.

C. Graphic software shall provide for multitasking such that third-party programs can be used while the OWS software is on line. Software shall provide the ability to alarm graphically even when operator is in another software package.

D. Operating system software shall be Microsoft Windows XP Professional, or latest version of Windows supported by the BAS manufacturer and approved by UC.

E. The software shall allow for the University’s creation of user-defined, color graphic displays of geographic maps, building plans, floor plans, and mechanical and electrical system schematics. These graphics shall be capable of displaying all point information from the database including any attributes associated with each point (i.e., engineering units, etc.). In addition, operators shall be able to command equipment or change setpoints from a graphic through the use of the mouse.

F. Screen Penetration: The operator interface shall allow users to access the various system graphic screens via a graphical penetration scheme by using the mouse to select from menus or ‘button’ icons. Each graphic screen shall be capable of having a unique list of other graphic screens that are directly linked through the selection of a menu item or button icon.

G. Dynamic Data Displays: Dynamic physical point values shall automatically updated at a minimum frequency of 6 updates per minute without operator intervention. Point value fields shall be displayed with a color code depicting normal, abnormal, override and alarm conditions.

H. Point Override Feature: Each displayed point shall be individually enabled/disabled to allow mouse-driven override of digital points or changing of analog points. Such overrides or changes shall occur in the control unit, not just in the workstation software. The graphic point override feature shall be subject to password level protection. Points that are overridden shall be reported as an alarm, and shall be displayed in a coded color. The alarm message shall include the operator’s user name. A list of points that are currently in an override state shall be available through menu selection.

I. Dynamic Symbols: Provide a selection of standard symbols that change in appearance based on the value of an associated point.
   1. Analog symbol: Provide a symbol that represents the value of an analog point as the length of a line or linear bar.
   2. Digital symbol: Provide symbols such as switches, pilot lights, rotating fan wheels, etc. to represent the value of digital input and output points.
   3. Point Status Color: Graphic presentations shall indicate different colors for different point statuses. (For instance, green = normal, red = alarm, gray (or ‘???’) for non-response).
   4. Terminal Equipment Color: Floor plan graphics shall be color coded by the equipment served as follows; green = zone temperature within setpoint, blue = zone temperature below setpoint, yellow = zone temperature above setpoint, red = zone temperature in alarm range.

J. Graphics Development Package: Graphic development and generation software shall be provided to allow the user to add, modify, or delete system graphic displays.
   1. The Contractor shall provide libraries of pre-engineered screens and symbols depicting standard air handling unit components (e.g. fans, cooling coils, filters, dampers, etc.), mechanical system components (e.g., pumps, chillers, cooling towers, boilers, etc.), complete mechanical systems (e.g. constant volume-terminal reheat, VAV, etc.) and electrical symbols.
   2. The Graphic Development Package shall use a mouse or similar pointing device to allow the user to perform the following:
      a) Define symbols
      b) Position items on graphic screens.
c) Attach physical or virtual points to a graphic  
d) Define background screens  
e) Define connecting lines and curves  
f) Locate, orient and size descriptive text  
g) Define and display colors for all elements  
h) Establish correlation between symbols or text and associated system points or other displays.  
i) Create hot spots or link triggers to other graphic displays or other functions in the software.  
j) Insert frames of html pages linked internally or externally to the CSS.

2.12 REMOTE PERSONAL COMPUTER WORKSTATION GRAPHIC SOFTWARE  
A. Remote graphic operator software shall provide all the functionality specified for the local graphic software.  
B. System configuration uses an Internet server and presents web pages that can be pulled up using a standard browser.  
C. Software shall be capable of initiating communication to system, upon user command, to perform all specified functions. Software shall be capable of initiating communication to the LANs in accordance with user-programmed time schedules to upload trend and report data. Software shall be capable of communicating from the LAN in accordance with user-programmed time schedules to report alarms, upload trend, and report data.

PART 3. EXECUTION  

3.01 SYSTEM CONFIGURATION  
A. Contractor shall thoroughly and completely configure BAS system software, supplemental software, network communications, CSS, OWS, remote operator workstation, portable operators terminal, printer, and remote communications.

3.02 SITE-SPECIFIC APPLICATION PROGRAMMING  
A. Provide all database creation and site-specific application control programming as required by these Specifications, national and local standards and for a fully functioning system. Contractor shall provide all initial site-specific application programming and thoroughly document programming. Generally meet the intent of the written sequences of operation. It is the Contractor’s responsibility to request clarification on sequence issues that require such clarification.  
B. All site-specific programming shall be fully documented and submitted for review and approval, both prior to downloading into the panel, at the completion of functional performance testing, and at the end of the warranty period.  
C. All programming, graphics and data files must be maintained in a logical system of directories with self-explanatory file names. All files developed for the project will be the property of the University and shall remain on the workstation(s)/server(s) at the completion of the project.

3.03 PASSWORD SETUP  
A. Set up the following password levels to include the specified capabilities:  
   1. Level 1: (University’s BAS Administrator)  
      a) Level 2 capabilities  
      b) View, add, change and delete user names, passwords, password levels
3. Level 3: (Senior Maintenance Technician)
   a) Level 4 capabilities
   b) Override output points
   c) Change setpoints
   d) Change equipment schedules
   e) Exit BAS software to use third party programs
4. Level 4: (Maintenance / Service Desk)
   a) Level 5 capabilities
   b) Acknowledge alarms
   c) Temporarily override equipment schedules
5. Level 5: (Read Only)
   a) Display all graphic data
   b) Trend point data

B. Contractor shall assist University’s operators with assigning user names, passwords and password levels. UCB has designated custom access levels for use by contractors actively using the system.

3.04 POINT PARAMETERS

A. Provide the following minimum programming for each analog input:
   1. Name
   2. Address
   3. Scanning frequency or COV threshold
   4. Engineering units
   5. Offset calibration and scaling factor for engineering units
   6. High and low alarm values and alarm differentials for return to normal condition
   7. High and low value reporting limits (reasonableness values), which shall prevent control logic from using shorted or open circuit values.
   8. Default value to be used when the actual measured value is not reporting. This is required only for points that are transferred across the primary and/or secondary controlling networks and used in control programs residing in control units other than the one in which the point resides. Events causing the default value to be used shall include failure of the control unit in which the point resides, or failure of any network over which the point value is transferred.
   9. Selectable averaging function that shall average the measured value over a user selected number of scans for reporting.

B. Provide the following minimum programming for each analog output:
   1. Name
   2. Address
   3. Output updating frequency
   4. Engineering units
5. Offset calibration and scaling factor for engineering units
6. Output Range
7. Default value to be used when the normal controlling value is not reporting.

C. Provide the following minimum programming for each digital input:
   1. Name
   2. Address
   3. Engineering units (on/off, open/closed, freeze/normal, etc.)
   4. Debounce time delay (Digital Filter)
   5. Message and alarm reporting as specified
   6. Reporting of each change of state, and memory storage of the time of the last change of state
   7. Totalization of on-time (for all motorized equipment status points), and accumulated number of off-to-on transitions.

D. Provide the following minimum programming for each digital output:
   1. Name
   2. Address
   3. Output updating frequency
   4. Engineering units (on/off, open/closed, freeze/normal, etc.)
   5. Direct or Reverse action selection
   6. Minimum on-time
   7. Minimum off-time
   8. Status association with a DI and failure alarming (as applicable)
   9. Reporting of each change of state, and memory storage of the time of the last change of state.
   10. Totalization of on-time (for all motorized equipment status points), and accumulated number of off-to-on transitions.
   11. Default value to be used when the normal controlling value is not reporting.

3.05 TRENDS

A. Contractor shall establish and store trend logs. Trend logs shall be prepared for each physical input and output point, and all dynamic virtual points such as setpoints subject to a reset schedule, intermediate setpoint values for cascaded control loops, and the like as directed by the University.

B. The University will analyze trend logs of the system operating parameters to evaluate normal system functionality. Contractor shall establish these trends and ensure they are being stored properly.
   1. Data shall include a single row of field headings and the data thereafter shall be contiguous. Each record shall include a date and time field or single date stamp. Recorded parameters for a given piece of equipment or component shall be trended at the same intervals and be presented in a maximum of two separate 2-dimensional formats with time being the row heading and field name being the column heading.

C. The Contractor shall demonstrate functional trends as specified for a period of 30 days after successful system demonstration before Substantial Completion of the system.

3.06 ALARMS

A. General: Contractor will be responsible for setting initial alarm parameters. Reporting actions will be setup by UCB. No reporting actions will be initiated unless directed by UCB.

B. Override Alarms: Any point that is overridden through the override feature of the graphic workstation software shall be reported as a Level 3 alarm.
C. **Analog Input Alarms**: For each analog input, program an alarm message for reporting whenever the analog value is outside of the programmed alarm limits. Report a ‘Return-to-Normal’ message after the analog value returns to the normal range, using a programmed alarm differential. The alarm limits shall be individually selected by UCB. Contractor shall coordinate with UCB for final values based on the following parameters:

1. **Space temperature, except as otherwise stated in sequence of operation**: Level 3
   a) Low alarm: 64°F
   b) Low return-to-normal: 68°F
   c) High alarm: 85°F
   d) High return-to-normal: 80°F
2. **Controlled media temperature other than space temperature** (e.g. AHU discharge air temperature, steam converter leaving water temperature, condenser water supply, chilled water supply, etc.): Level 3 (If controlled media temperature setpoint is reset, alarm setpoints shall be programmed to follow setpoint)
   a) Low alarm: 3°F below setpoint
   b) Low return-to-normal: 2°F below setpoint
   c) High alarm: 3°F above setpoint
   d) High return-to-normal: 2°F above setpoint.
3. **AHU mixed air temperature**: Level 4
   a) Low alarm: 45°F
   b) Low return-to-normal: 46°F
   c) High alarm: 90°F
   d) High return-to-normal: 89°F
4. **Duct Pressure**:
   a) Low alarm: 0.5”w.g. below setpoint
   b) Low return-to-normal: 0.25”w.g. below setpoint
   c) High alarm: 0.5”w.g. above setpoint
   d) High return-to-normal: 0.25”w.g. above setpoint
5. **Space humidity**:
   a) Low alarm: 35%
   b) Low return-to-normal: 40%
   c) High alarm: 75%
   d) High return-to-normal: 70%

D. **BAS System Failure Alarm**: Generate alarm that reads “BAS System Failure”. Alarm shall be generated when communication is lost to any controller or when any controller is determined to be in an abnormal state.

### 3.07 GRAPHIC SCREENS

A. **Floor Plan Screens**: The contract document drawings will be made available to the Contractor in AutoCAD format upon request. These drawings may be used only for developing backgrounds for specified graphic screens; however the University does not guarantee the suitability of these drawings for the Contractor’s purpose.

1. Provide graphic floor plan screens for each floor, wing, or tower of the building. Indicate the location of all equipment that is not located on the equipment room screens. Indicate all equipment zones with corresponding ON/OFF status. Indicate the location of temperature sensors associated with each temperature-controlled zone (i.e., VAV terminals, fan-coils, single-zone AHUs, etc.) on the floor plan screens. Display the space temperature point...
adjacent to each temperature sensor symbol. Use a distinct line symbol to demarcate each terminal unit zone boundary. Use distinct colors to demarcate each air handling unit zone. Mechanical floor plan drawings will be made available to the contractor upon request for the purpose of determining zone boundaries. Indicate room numbers as provided by the Owner. Provide a drawing link from each space temperature sensor symbol and equipment symbol shown on the graphic floor plan screens to each corresponding equipment schematic graphic screen.

2. Provide graphic floor plan screens for each mechanical equipment room and a plan screen of the roof. Indicate the location of each item of mechanical equipment. Provide a drawing link from each equipment symbol shown on the graphic plan view screen to each corresponding mechanical system schematic graphic screen.

3. If multiple floor plans are necessary to show all areas, provide a graphic building key plan. Use elevation views and/or plan views as necessary to graphically indicate the location of all of the larger scale floor plans. Link graphic building key plan to larger scale partial floor plans. Provide links from each larger scale graphic floor plan screen to the building key plan and to each of the other graphic floor plan screens.

4. Provide a graphic site plan with links to and from each building plan.

B. System Schematic Screens: Provide graphic system schematic screen for each HVAC subsystem controlled with each I/O point in the project appearing on at least one graphic screen. System graphics shall include flow diagrams with status, setpoints, current analog input and output values, operator commands, etc. as applicable. General layout of the system shall be schematically correct. Input/output devices shall be shown in their schematically correct locations. Include appropriate engineering units for each displayed point value. Verbose names (English language descriptors) shall be included for each point on all graphics; this may be accomplished by the use of a pop-up window accessed by selecting the displayed point with the mouse. Indicate all adjustable setpoints on the applicable system schematic graphic screen or, if space does not allow, on a supplemental linked-setpoint screen.

1. Provide graphic screens for each air handling system. Indicate outside air temperature and enthalpy, and mode of operation as applicable (i.e., occupied, unoccupied, warm-up, cool-down). Link screens for air handlers to the heating system and cooling system graphics. Link screens for supply and exhaust systems if they are not combined onto one screen.

2. Provide a graphic screen for each zone. Provide links to graphic system schematic screens of air handling units that serve the corresponding zone.

3. Provide a cooling system graphic screen showing all points associated with the chillers, cooling towers and pumps. Indicate outside air dry-bulb temperature and calculated wet-bulb temperature. Link screens for chilled water and condenser water systems if they cannot fit onto one cooling plant graphic screen.

4. Link screens for heating and cooling system graphics to utility history reports showing current and monthly electric uses, demands, peak values, and other pertinent values.

C. Alarms: Each programmed alarm shall appear on at least one graphic screen. In general, alarms shall be displayed on the graphic system schematic screen for the system that the alarm is associated with (for example, chiller alarm shall be shown on graphic cooling system schematic screen). For all graphic screens, display analog and digital values that are in a ‘alarm’ condition in a red color.
SECTION 230913
BAS BASIC MATERIALS, INTERFACE DEVICES, AND SENSORS

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PART 1 GENERAL

1.01 SECTION INCLUDES
A. Wiring
B. Control Valves and Actuators
C. Control Dampers and Actuators
D. Control Panels
E. Sensors
F. Flow Meter
G. Electric Control Components (Switches, EP Valves, Thermostats, Relays, Smoke Detectors, etc.)
H. Transducers
I. Air Flow Measuring Stations
J. Current Switches
K. Nameplates
L. Testing Equipment

1.02 RELATED DOCUMENTS
A. Section 23 05 00 - Basic Mechanical Requirements
B. Section 23 0900 – Building Automation System (BAS) General
C. Section 23 0902 - BAS Operator Interfaces
D. Section 23 0903 - BAS Field Panels
E. Section 23 0904 - BAS Communication Devices
F. Section 23 0905 - BAS Software and Programming
G. Section 23 0993 - Sequences of Operation
H. Section 23 0801 - BAS Commissioning

1.03 DESCRIPTION OF WORK
A. Refer to Section 23 0900 for general requirements.
B. Refer to other Division-23 sections for installation of instrument wells, valve bodies, and dampers in mechanical systems; not work of this section.
C. Provide the following electrical work as work of this section, complying with requirements of Division-26 sections:
   1. Control wiring between field-installed controls, indicating devices, and unit control panels.
   2. Interlock wiring between electrically interlocked devices, sensors, and between a hand or auto position of motor starters as indicated for all mechanical and controls.
   3. Wiring associated with indicating and alarm panels (remote alarm panels) and connections to their associated field devices.
   4. All other necessary wiring for fully complete and functional control system as specified.

1.04 WORK BY OTHERS
A. Control Valves furnished under this section shall be installed under the applicable piping section under the direction of Section 23 0913 Contractor who will be fully responsible for the proper operation of the valve.
B. Control Dampers furnished under this section shall be installed under the applicable air distribution or air handling equipment section under the direction of Section 23 0913 Contractor who will be fully responsible for the proper operation of the damper
C. Water Pressure Taps, Thermal Wells, Flow Switches, Flow Meters, etc. that will have wet surfaces, shall be installed under the applicable piping Section under the direction of Section 23 0913 Contractor who will be fully responsible for the proper installation and application.
D. Controlled Equipment Power Wiring shall be furnished and installed under Division 26. Where control involves 120V control devices controlling 120V equipment, Division 26 Contractor shall extend power wiring to the equipment and control panel. Section 23 0913 Contractor shall extend it from the equipment to the control device and provide transformers as necessary to step the voltage down.

PART 2 PRODUCTS

2.01 MATERIALS AND EQUIPMENT

A. General: Provide electronic control products in sizes and capacities indicated, consisting of valves, dampers, thermostats, clocks, controllers, sensors, and other components as required for complete installation and reviewed and approved by UC. Except as otherwise indicated, provide manufacturer's standard materials and components as published in their product information; designed and constructed as recommended by manufacturer, and as required for application indicated.

B. Instrument Pipe and Tube

1. Hydronic and Instruments
   a) Connection to Main Piping: Provide ½ inch minimum size threadolet, ½” x 2 inch brass nipple, and ½” ball valve for connection to welded steel piping. Provide tee fitting for other types of piping.
   b) Remote Instruments: Adapt from ball valve to specified tubing and extend to remote instruments. Provide a union or otherwise removable fitting at ball valve so that connection to main can be cleaned with straight rod. Where manifolds with test ports are not provided for instrument, provide tees with ¼” FPT branch with plug for use as test port. Adapt from tubing size to instrument connection.
   c) Line Mounted Instruments: Extend rigid piping from ball valve to instrument. Do not use close or running thread nipples. Adapt from ball valve outlet to instrument connection size. Provide a plugged tee if pipe makes 90 degree bend at outlet of valve to allow cleaning of connection to main with straight rod without removing instrument.
   d) Instrument Tubing: Seamless copper tubing, Type K or L, ASTM B 88; with cast-bronze solder joint fittings, ANSI B1.18; or wrought-copper solder-joint fittings, ANSI B16.22; or brass compression-type fittings. Solder shall be 95/5 tin antimony, or other suitable lead free composition solder. Tubing OD size shall be not less than the larger of ¼” or the instrument connection size.
   e) Rigid Piping for Line Mounted Instruments: Schedule 40 threaded brass, with threaded brass fittings.

2. Low Pressure Air Instrument Sensing Lines
   a) Connections: Use suitable bulkhead type fitting and static sensing tip for static pressure connections. Adapt tubing to instrument connection.
   b) Tubing: Virgin polyethylene non-metallic tubing type FR, ASTM D 2737, and with flame-retardant harness for multiple tubing. Use compression or push-on brass fittings.

C. Communication Wiring: All wiring shall be in accordance with manufacturer’s requirements, National Electrical Codes and Division 16 of this specification. All wire insulation shall be color-coded and labeled for ease of identification.
1. Contractor shall supply all communication wiring between Building Controllers, Routers, Gateways, AAC’s, ASC’s and local and remote peripherals (e.g., operator workstations, printers, and modems).

2. Local Supervisory LAN: For any portions of this network required under this section of the specification, contractor shall use Fiber or Category 5e of standard TIA/EIA (100/1000BaseT). Network shall be run with no splices and in separate conduit from any other wiring.

3. Primary and Secondary Controller LANs: Communication wiring shall be individually 100% shielded pairs per manufacturers recommendations for distances installed, with overall PVC cover, Class 2, plenum-rated run with no splices and separate from any other wiring. Shield shall be terminated and wiring shall be grounded as recommended by BC manufacturer.

D. Signal Wiring: Contractor shall run all signal wiring in accordance with National Electric Codes, Division 26 of this Specification and within the allowances of UCB’s wiring guideline. All wire insulation shall be color-coded and labeled for ease of identification.

1. Signal wiring to all field devices, including, but not limited to, all sensors, transducers, transmitters, switches, etc. shall be per manufacturer’s requirements. Signal wiring shall be run with no splices and separate from all other wiring above thirty (30) volts.

2. Signal wiring shield shall be grounded at controller end only unless otherwise recommended by the controller manufacturer.

E. Low Voltage Analog Output Wiring: Contractor shall run all low voltage control wiring in accordance with National Electric Codes and Division 26 of this Specification. All wire insulation shall be color-coded and labeled for ease of identification.

1. Low voltage control wiring shall be per manufacturer’s requirements. Low voltage control wiring shall be run with no splices separate from any wiring above thirty (30) volts.

F. Control Panels: Provide control panels with suitable brackets for wall mounting for each control system. Locate panel adjacent to systems served.

1. Fabricate panels of 16-gage furniture-grade steel, or 6063-T5 extruded aluminum alloy, totally enclosed on four sides, with hinged door and keyed lock, with manufacturer's standard shop-painted finish and color.

2. Provide UL-listed cabinets for use with line voltage devices.

3. Control panel shall be completely wired prior to delivery and all electrical connections made to a labeled terminal strip. Control panel shall have standard manufacturer's color.

4. All gauges and control components shall be identified by means of nameplates.

5. All control wiring shall be run neatly and orderly in open slot wiring duct with cover.

6. Complete wiring termination drawings shall be mounted in or adjacent to panel.

2.02 CONTROL VALVES

A. General: Provide factory fabricated control valves of type, body material and pressure class indicated. They shall be two-way or three-way type for two-position or modulating service as scheduled, shown on drawings, or as specified in Sequence of Operation.
B. Close-Off (differential) Pressure Rating: Valve actuator and trim shall be furnished to provide the following minimum close-off pressure ratings:

1. Water Valves:
   a) Two-way - 150% of total system (pump) head.
   b) Three-way - 300% of pressure differential between ports A and B at design flow or 100% of total system (pump) head.

2. Steam Valves:
   a) 150% of operating (inlet) pressure.

C. Water Valves:

1. Body and trim style and materials shall be per manufacturer's recommendations for design conditions and service shown, with equal percentage ports for modulating service, except where stated otherwise.

2. Sizing Criteria:
   a) Two-position service: Full port line size.
   b) Two-way modulating service: Pressure drop across the valve in a wide-open position, with full flow through the valve, shall be equal to 50% of the available pressure differential between the mains, with a minimum of 4 psi.
   c) Three-way Modulating Service: Pressure drop across the valve in a wide-open position, with full flow through the valve, shall be equal to twice the pressure drop through the heat exchanger (load), with a 3 psi minimum.

3. Construction:
   a) Valves ½” through ¾” globe style serving terminal units, AHU coils and baseboard radiation shall be:
      1) Honeywell VP-525A or C series:
         i. 2-way, N.O., VP-526A OR 2-way, N.O., VP-531A
         ii. 3-way, VP-527A
         iii. C series, 2-way, N.O. OR preapproved equal (Siemens Powermite599 Series (electric) or Siemens Powermite 599 (pneumatic))
   b) Valves 1"and 1¼” for sequencing applications may be:
      i. Powers VP-658 (2-way, N.O. or N.C.)
      ii. Powers VP-658WM (3-way), VP-591 also acceptable
   c) Valves 1” through 8” globe style for control of differential pressure shall be:
      1) Siemens 200 series electric actuators or pre-approved equal.
   d) Valves 2" through 12” butterfly style for control of condenser water temperature (cooling tower bypass) shall be:
      1) Siemens 2-way butterfly assemblies with Siemens electric actuators or pre-approved equal.
   e) Valves 2” through 12” single butterfly style two-position or modulated applications shall be:
      1) Johnson VF Series Powers/Siemens BV2W Series with electric actuator or pre-approved equal.

4. Water valves shall fail as specified in the Control Sequences section.

5. Evaporative Cooler Drain and Fill Valves:
   a) Valve normal position shall be as shown on the drawings.
6. For systems with glycol solutions, provide documentation that the valve components in contact with the fluid are compatible with it.

D. Steam Valves:
1. Body and trim materials shall be per manufacturer's recommendations for design conditions and service, except stainless steel seats are required for all applications. Equal percentage ports for modulating service.
2. Sizing Criteria:
   a) Two-position Service - pressure drop 10 to 20% of inlet psig.
   b) Modulating Service - 15 psig or less. Pressure drop 80% of inlet psig.
   c) Modulating Service - 16 to 50 psig. Pressure drop 50% of inlet psig.
   d) Modulating Service - over 50 psig. Pressure drop as scheduled on plans.
3. Steam valves shall fail normally open or closed as scheduled on plans or as follows:
   a) High-pressure applications - as scheduled.
4. Acceptable manufacturers as follows:
   a) Globe style; terminal units, baseboard radiation.
      1) ½” through ¾”; Honeywell VP-525A (N.O., 2-way).
      2) Siebe VB-9223 (N.C., 2-way).
      3) Powers 591/593 (N.O. or N.C. 2-way) series.
   b) Globe style; steam/water heat exchangers, AHU coils.
      1) 1” through 2”; Powers 591/593 series.
      2) 2 ½” through 4”; Powers 591/593 series, Fisher Easy-E series, Leslie Class DLOS-2.
   c) Smart Steam Valves (for Mains): Keystone valves with Peaktronics DHC-100 series or pre-approved equal.

2.03 CONTROL DAMPERS
A. General: Provide factory fabricated automatic control dampers of sizes, velocity and pressure classes as required for smooth, stable, and controllable air flow. Provide parallel or opposed blade dampers as recommended by manufacturers sizing techniques. For dampers located near fan outlets, provide dampers rated for fan outlet velocity and close-off pressure, and recommended by damper manufacturer for fan discharge damper service. Control dampers used for smoke dampers shall comply with UL 555S. Control Dampers used for fire dampers shall comply with UL 555.
B. For general isolation and modulating control service in rectangular ducts at velocities not greater than 1500 fpm (7.62 m/s), differential pressure not greater than 2.5” w.c. (622 Pa):
   1. Performance: Test in accordance with AMCA 500.
   2. Frames: Galvanized steel, 16-gauge minimum thickness, welded or riveted with corner reinforcement.
   3. Blades: Stainless steel in lab exhausts and galvanized steel elsewhere, maximum blade size 8 inches (200 mm) wide by 48 inches (1219 mm) long, attached to minimum 1/2 inch (12.7 mm) shafts with set screws, 16 gauge minimum thickness.
6. Shaft Bearings: Oil impregnated sintered bronze, graphite impregnated nylon sleeve or other molded synthetic sleeve, with thrust washers at bearings.

7. Linkage: Concealed in frame.

8. Linkage Bearings: Oil impregnated sintered bronze or graphite impregnated nylon.

9. Leakage: Less than one percent based on approach velocity of 1500 ft./min. (7.62 m/s) and 1 inches wg. (249Pa).

10. Maximum Pressure Differential: 2.5 inches wg. (622 Pa)

11. Temperature Limits: -40 to 200 °F (-40 to 93 °C).

12. Where opening size is larger than 48 inches (1219 mm) wide, or 72 inches (1829 mm) high, provide dampers in multiple sections, with intermediate frames appropriate for installation.

C. For general isolation and modulating control service in rectangular ducts at velocities not greater than 4000 fpm (20.3 m/s), differential pressure not greater than 6” w.c. (1493 Pa):

1. Performance: Test in accordance with AMCA 500.

2. Frames: Galvanized steel, 16-gauge minimum thickness, welded or riveted with corner reinforcement.

3. Blades: Extruded aluminum hollow airfoil shape, maximum blade size 8 inches (200 mm) wide by 48 inches (1219 mm) long, attached to minimum 1/2 inch (12.7 mm) shafts, 14 gauge minimum extrusion thickness.


6. Shaft Bearings: Oil impregnated sintered bronze sleeve, graphite impregnated nylon sleeve, molded synthetic sleeve, or stainless steel sleeve, with thrust washers at bearings.

7. Linkage: Concealed in frame.

8. Linkage Bearings: Oil impregnated sintered bronze or graphite impregnated nylon.

9. Leakage: Less than 0.1 percent based on approach velocity of 4000 ft./min. (20.3 m/s) and 1 inches wg. (249Pa).

10. Maximum Pressure Differential: 6 inches wg. (622 Pa)

11. Temperature Limits: -40 to 200 °F (-40 to 93 °C).

12. Where opening size is larger than 48 inches (1219 mm) wide, or 72 inches (1829 mm) high, provide dampers in multiple sections, with appropriately intermediate frames.

D. For general isolation and modulating control service in rectangular ducts at velocities not greater than 4000 fpm, differential pressure not greater than 12” w.c.:

1. Performance: Test in accordance with AMCA 500.

2. Frames: Galvanized steel, 12-gauge minimum thickness, welded or riveted with corner reinforcement.

3. Blades: Extruded aluminum hollow airfoil shape, maximum blade size 8 inches (200 mm) wide by 48 inches (1219 mm) long, attached to minimum 3/4 inch (19 mm) shafts with set screws.

4. Shaft Bearings: Oil impregnated sintered bronze or stainless steel, pressed into frame, with thrust washers at bearings.
5. Linkage: 10-gauge minimum thickness galvanized steel clevis type crank arms, 3/16” x 3/4” (4.76 mm x 19 mm) minimum thickness tie rods.
6. Linkage Bearings: Oil impregnated sintered bronze or graphite impregnated nylon.
7. Leakage: Less than 0.2 percent based on approach velocity of 4000 ft./min. (20.3 m/s) and 1 inches wg. (249Pa) differential pressure.
8. Maximum Pressure Differential: 12 inches wg. (2984 Pa)
9. Temperature Limits: -40 to 300 °F (-40 to 149 °C).
10. Where opening size is larger than 48 inches (1219 mm) wide, or 72 inches (1829 mm) high, provide dampers in multiple sections, with appropriately intermediate frames, and jackshafts.

E. For general isolation and modulating control service in round ducts up to 40 inches in size at velocities not greater than 2500 fpm (12.7 m/s), differential pressure not greater than 4” w.c. (994 Pa):
1. Performance: Test in accordance with AMCA 500.
2. Frames: rolled 12 gauge steel strip for sizes 6 inch and smaller, rolled 14 gauge steel channel for larger sizes, galvanized or aluminum finish.
3. Blades: Steel construction, 12 gauge minimum thickness for dampers less than 18 inches (457 mm) in size, 10 gauge minimum thickness for larger dampers.
5. Shaft: ½ inch (12.7 mm) diameter zinc or cadmium plated steel.
6. Shaft Bearings: Oil impregnated sintered bronze or stainless steel, pressed into frame, with thrust washers at bearings.
7. Leakage: Less than 0.2 percent based on approach velocity of 4000 ft./min. (20.3 m/s) and 1 inches wg. (249Pa) differential pressure.
8. Maximum Pressure Differential: 4 inches wg. (994 Pa)
9. Temperature Limits: -40 to 300 °F (-40 to 149 °C).

F. For general isolation and modulating control service in round ducts up to 60 inches in size at velocities not greater than 4000 fpm (20.3 m/s), differential pressure not greater than 6” w.c. (1492 Pa):
1. Performance: Test in accordance with AMCA 500.
2. Frames: rolled 10-gauge steel channel for sizes 48 inch and smaller, rolled 3/16 inch (4.76 mm) thick steel channel for larger sizes, galvanized or aluminum finish.
3. Blades: Steel construction, 10-gauge minimum thickness for dampers not greater than 48 inches in size, ¼ inch (6.35 mm) minimum thickness for larger dampers.
4. Blade stops: ½ inch x ¼ inch (12.7 mm x 6.35 mm) full circumference steel bar.
6. Shaft: zinc or cadmium plated steel, angle reinforcing as necessary.
7. Shaft Bearings: Oil impregnated sintered bronze or stainless steel, pressed into frame, with thrust washers at bearings.
8. Leakage: Less than 0.4 percent based on approach velocity of 4000 ft./min. (20.3 m/s) and 1 inches wg. (249Pa) differential pressure.
10. Temperature Limits: -40 to 250 °F (-40 to 121 °C).
2.04 ACTUATORS

A. General: Size actuators and linkages to operate their appropriate dampers or valves with a single actuator with sufficient reserve torque or force to provide smooth modulating action or 2-position action as specified. Multiple actuators for any single application must be preapproved by UCB. Select spring-return actuators with manual override to provide positive shut-off of devices as they are applied. Actuators relying on batteries for any operation are not acceptable.

B. Damper Actuators
   1. Ambient Operating Temperature Limits: -10 to 150°F (-12.2 to 66 °C)
   2. Two Position Electric Actuators: Low voltage or line voltage with spring return.
      a) Acceptable Manufacturers:
         1) Siemens
         2) Belimo
         3) Johnson Controls
         4) Substitutions: or approved equal
   3. Electronic Actuators: Provide actuators with spring return for two-position (24v), 0-5 Vdc, 0-10 Vdc, 2-10Vdc, 4-20 mA, or PWM input (subject to restrictions) as required. Actuators shall travel full stroke in less than [90] seconds. Actuators shall be designed for a minimum of 60,000 full cycles at full torque and be UL 873 listed. Provide stroke indicator. Actuators shall have positive positioning circuit. Where two actuators are required in parallel or in sequence provide an auxiliary actuator driver. Actuators shall have current limiting motor protection. Actuators shall have manual override where indicated.
      a) Close-Off Pressure: Provide the minimum torque required, and spring return for fail positioning (unless otherwise specifically indicated) sized for required close-off pressure. Required close-off pressure for two-way water valve applications shall be the shutoff head of associated pump. Required close-off rating of steam valve applications shall be design inlet steam pressure plus 50 percent for low pressure steam, and 10 percent for high pressure steam. Required close-off rating of air damper applications shall be shutoff pressure of associated fan, plus 10 percent.
      b) Acceptable Manufacturers: Subject to compliance with requirements approved manufacturers are as follows:
         1) Belimo
         2) Johnson Controls
         3) Invensys
         4) Substitutions: Must be pre-approved by UCB
   C. Quarter-Turn Actuators (for ball and butterfly valves):
      1. Electric
         a) Motor: Suitable for 120 or 240 Volt single-phase power supply. Insulation shall be NEMA Class F or better. Motor shall be rated for 100 percent duty cycle. Motors shall have inherent overload protection.
         b) Gear Train. Motor output shall be directed to a self locking gear drive mechanism. Gears shall be rated for torque input exceeding motor locked rotor torque.
c) Wiring: Power and control wiring shall be wired to a terminal strip in the actuator enclosure

d) Failsafe Positioning: Actuators shall be spring return type for failsafe positioning.

e) Enclosure: Actuator enclosure shall be NEMA-4 rated, and shall have a minimum of two threaded conduit entries. Provide an enclosure heater for actuators located outside of buildings.

f) Limit Switches: Travel limit switches shall be UL and CSA approved. Switches shall limit actuator in both open and closed positions.

g) Mechanical Travel Stops: The actuator shall include mechanical travel stops of stainless steel construction to limit actuator to specific degrees of rotation.

h) Manual Override: Actuators shall have manual actuator override to allow operation of the valve when power is off. For valves 4 inches and smaller the override may be a removable wrench or lever or geared handwheel type. For larger valves, the override shall be a fixed geared handwheel type. An automatic power cut-off switch shall be provided to disconnect power from the motor when the handwheel is engaged for manual operation.

i) Valve Position Indicator: A valve position indicator with arrow and open and closed position marks shall be provided to indicate valve position.

j) Torque Limit Switches: Provide torque limit switches to interrupt motor power when torque limit is exceeded in either direction of rotation.

k) Position Controller: For valves used for modulating control, provide an electronic positioner capable of accepting 4-20 mA, 0-10 Vdc, 2-10 Vdc, and 135 Ohm potentiometer.

l) Ambient Conditions: Actuator shall be designed for operation from –140 to 150 °F ambient temperature with 0 to 100 percent relative humidity.

m) Acceptable Manufacturers:
   1) Siemens
   2) Belimo
   3) Substitutions: approved equal

2.05 GENERAL FIELD DEVICES

A. Provide field devices for input and output of digital (binary) and analog signals into controllers (BCs, AACs, ASCs). Provide signal conditioning for all field devices as recommended by field device manufacturers, and as required for proper operation in the system.

B. It shall be the Contractor's responsibility to assure that all field devices are compatible with controller hardware and software.

C. Field devices specified herein are generally ‘two-wire’ type transmitters, with power for the device to be supplied from the respective controller. If the controller provided is not equipped to provide this power, or is not designed to work with ‘two-wire’ type transmitters, or if field device is to serve as input to more than one controller, or where the length of wire to the controller will unacceptably affect the accuracy, the Contractor shall provide ‘four-wire’ type equal transmitter and necessary regulated DC power supply or 120 VAC power supply, as required.
D. For field devices specified hereinafter that require signal conditioners, signal boosters, signal repeaters, or other devices for proper interface to controllers, Contractor shall furnish and install proper device, including 120V power as required. Such devices shall have accuracy equal to, or better than, the accuracy listed for respective field devices.

E. Accuracy: As stated in this Section, accuracy shall include combined effects of nonlinearity, non-repeatability and hysteresis.

2.06 TEMPERATURE SENSORS (TS)

A. Sensor range: When matched with A/D converter of BC, AAC/ASC, or SD, sensor range shall provide a resolution of no worse than 0.3°F (0.16 °C) (unless noted otherwise). Where thermistors are used, the stability shall be better than 0.25°F over 5 years.

B. Matched Sensors: The following applications shall require matched sensors:

1. Building Loop Connections: Provide matched loop and building supply sensors where control sequence requires controlling to a temperature rise (differential).

2. Hydronic Temperature Difference Calculations: Provide matched supply and return temperature sensors where the pair is used for calculating temperature difference for use in load calculations or sequencing such as across chillers and plants.

C. Room Temperature Sensor: Shall be an element contained within a ventilated cover, suitable for wall mounting. Provide insulated base. Following sensing elements are acceptable:

1. Sensing element shall be platinum RTD, thermistor, or integrated circuit, +/- 0.4°F accuracy at calibration point.

2. Provide setpoint adjustment where indicated. The setpoint adjustment shall be a warmer/cooler indication that shall be scalable via the BAS (initial range of +/- 2°F).

3. Provide an occupancy override button on the room sensor enclosure where indicated. This shall be a momentary contact closure

4. Provide current temperature indication via an LCD readout where indicated.

D. Single-Point Duct Temperature Sensor: Shall consist of sensing element, junction box for wiring connections and gasket to prevent air leakage or vibration noise. Temperature range as required for resolution indicated in paragraph A. Sensor probe shall be 316 stainless steel.

1. Sensing element shall be platinum RTD, thermistor, or integrated circuit, +/- 0.2°F accuracy at calibration point

E. Averaging Duct Temperature Sensor: Shall consist of an averaging element, junction box for wiring connections and gasket to prevent air leakage. Provide sensor lengths and quantities to result in one linear foot of sensing element for each three square feet of cooling coil/duct face area. Temperature range as required for resolution indicated in paragraph A.

1. Sensing element shall be platinum RTD, or thermistor, +/- 0.2°F accuracy at calibration point

F. Liquid immersion temperature sensor shall include brass thermowell, sensor and connection head for wiring connections. Temperature range shall be as required for resolution of 0.15°F.
1. Sensing element shall be platinum RTD, thermistor, or integrated circuit, +/- 0.4°F accuracy at calibration point. Temperature range shall be as required for resolution of 0.3°F.

G. Pipe Surface-Mount Temperature Sensor: Shall include metal junction box and clamps and shall be suitable for sensing pipe surface temperature and installation under insulation. Provide thermally conductive paste at pipe contact point. Temperature range shall be as require for resolution indicated in paragraph A.

1. Sensing element shall be platinum RTD, thermistor, or integrated circuit, +/- 0.4°F accuracy at calibration point.

H. Outside air sensors shall consist of a sensor, sun shield, utility box, and watertight gasket to prevent water seepage. Temperature range shall be as require for resolution indicated in Paragraph A

1. Sensing element shall be platinum RTD, thermistor, or integrated circuit, +/- 0.4°F accuracy at calibration point.

2.07 HUMIDITY TRANSMITTERS

A. Units shall be suitable for duct, wall (room) or outdoor mounting. Unit shall be two-wire transmitter utilizing bulk polymer resistance change or thin film capacitance change humidity sensor. Unit shall produce linear continuous output of 4-20 mA for percent relative humidity (% RH). A combination temperature and humidity sensor may be used for zone level monitoring. Sensors shall have the following minimum performance and application criteria:

1. Input Range: 0 to 100% RH.
2. Accuracy (% RH): +/- 2% (when used for enthalpy calculation, dewpoint calculation or humidifier control) or +/- 3% (monitoring only) between 20-90% RH at 77°F, including hysteresis, linearity, and repeatability.
3. Sensor Operating Range: As required by application
4. Long Term Stability: Less than 1% drift per year.

B. Acceptable Manufacturers: Units shall be Vaisala HM Series. Substitutions shall be allowed per Division 1.

2.08 DIFFERENTIAL PRESSURE TRANSMITTERS (DP)

A. General Purpose - Water: Two-wire transmitter, 4-20 mA output with zero and span adjustments. Plus or minus 0.5% overall accuracy, 450 psig (3103 KPa) maximum static pressure rating, 200 psid maximum overpressure rating for 6 through 60 psid range, 450 psid for 100 through 300 psid range.

B. Industrial Application, Liquid, Steam and Gas:

1. General: Two-wire smart DP cell type transmitter, 4-20 mA or 1-5 Vdc user-selectable linear or square root output, adjustable span and zero, stainless steel wetted parts.
2. Environmental limits: -40 to 250 °F (-40 to 121°C), 0 to 100% RH.
3. Accuracy: less than 0.1 percent of span.
4. Output Damping: Time constant user selectable from 0 to 36 seconds.
5. Vibration Effect: Less than ±0.1% of upper range limit from 15 to 2000 Hz in any axis relative to pipe mounted process conditions.
7. Approvals: FM, CSA.
8. Acceptable Manufacturers: Rosemount Inc. 3051 Series, Foxboro, Johnson-Yokagawa, Setra, or Mamac. Substitutions shall be allowed per Division 1.

C. General Purpose Low Pressure Air: Generally for use in static measurement of duct pressure or constant volume air velocity pressure measurement where the range is applicable.
   1. General: Loop powered two-wire differential capacitance cell-type transmitter.
   2. Output: two wire 4-20 mA output with zero adjustment.
   3. Overall Accuracy: Plus or minus 1%.
   4. Minimum Range: 0.1 in. w.c.
   5. Maximum Range: 10 inches w.c.
   6. Housing: Polymer housing suitable for surface mounting.
   8. Static Sensing Element: Pitot-type static pressure sensing tips similar to Dwyer model A-301 and connecting tubing.
   9. Range: Select for specified setpoint to be between 25% and 75% full-scale.

D. General Purpose Low Pressure/Low Differential Air: Generally for use in static measurement of space pressure or constant volume air velocity pressure measurement where the range is applicable.
   1. General: Loop powered, two-wire differential capacitance cell type transmitter.
   2. Output: Two-wire, 4-20 mA output with zero adjustment.
   3. Overall Accuracy: Plus or minus 1%.
   4. Minimum Range: 0 in. w.c.
   5. Maximum Range: 0.1, 0.25, or 0.5 inches w.c.
   6. Housing: Polymer housing suitable for surface mounting.
   8. Static Sensing Element: Pitot-type static pressure sensing tips similar to Dwyer model A-301 and connecting tubing.
   9. Range: Select for specified setpoint to be between 25% and 75% full-scale.

E. VAV Velocity Pressure: Generally for use in variable volume air velocity pressure measurement where the range is applicable.
   1. General: Loop powered two-wire differential capacitance cell type transmitter.
   2. Output: Two-wire, 4-20 mA output with zero adjustment.
   3. Overall Accuracy: Plus or minus 0.25%
   4. Minimum Range: 0 in. w.c.
   5. Maximum Range: 1 inch w.c.
   6. Housing: Polymer housing suitable for surface mounting.
   7. Acceptable Manufacturers: Setra. Substitutions shall be allowed per Division 1.
8. Range: Select for minimum range that will accept the maximum velocity pressure expected.

2.09 VALVE BYPASS FOR DIFFERENTIAL PRESSURE SENSORS
   A. Provide a three or five valve bypass kit for protection of DP sensors where the static on the pipe can cause on over pressure when connected to one port with the other at atmospheric pressure. Kit shall include high and low pressure isolation valves, high and low pressure vent valves (five valve kit) and a bypass valve contained in a NEMA-1 enclosure. Enclosure shall be mounted no higher than 6 feet above floor level.

2.10 DIFFERENTIAL PRESSURE SWITCHES (DPS)
   A. General Service - Air: Diaphragm with adjustable setpoint and differential and snap acting form C contacts rated for the application. Provide manufacturer's recommended static pressure sensing tips and connecting tubing
   B. General Service - Water: Diaphragm with adjustable setpoint, 2 psig or adjustable differential, and snap-acting Form C contacts rated for the application. 60 psid minimum pressure differential range. 0°F to 160°F operating temperature range.

2.11 PRESSURE SWITCHES (PS)
   A. Diaphragm or bourdon tube with adjustable setpoint and differential and snap-acting Form C contacts rated for the application. Pressure switches shall be capable of withstanding 150% of rated pressure.
   B. Acceptable Manufacturers: Square D, ITT Neo-Dyn, ASCO, Penn, Honeywell, and Johnson Controls. Substitutions shall be allowed per Division 1.

2.12 TRANSDUCERS
   A. Standard Capacity Electronic-to-Pneumatic (E-P) Transducers: E-P transducers shall be Voltage-to-Pneumatic (V-P) type, Current-to-Pneumatic (I-P) type:
      1. Electrical Power Supply: 24 Vac or 24 Vdc.
      2. Pneumatic Air Supply: 30 psig (2.07 bar) maximum.
      3. Air Capacity: 1100 scim @ 20 psig (300 cm³/sec @ 1.4 bar).
      4. Air Consumption: Zero at steady state.
      5. Output Span: 0-20 psig (0-1.4 bar).
      6. Input: 4-20 mA, 0-5 Vdc, 1-5 Vdc, 0-10 Vdc, 2-10 Vdc, 0-15 Vdc, or 3-15 Vdc input.
      7. Enclosure: Polymer designed for surface or panel mount.
      8. Air Connections: ¼” (6.35 mm) barbed.
      9. Failure Mode on Power Loss: Non-failsafe transducers shall have no output air loss. Failsafe transducers shall exhaust output upon power loss.
   10. Acceptable Manufacturers: Mamec EP-313-020, Johnson Controls. Substitutions shall be allowed per Division 1

2.13 CURRENT TRANSDUCER (CT)
   A. Clamp-On Design Current Transducer (for Motor Current Sensing)
1. Range: 1-10 amps minimum, 20-200 amps maximum
2. Trip Point: Adjustable
3. Output: 0-5 VDC.
4. Accuracy: ±0.2% from 20 to 100 Hz.
5. Acceptable Manufacturers: KELE SA100. Substitutions shall be allowed per Division 1.

2.14 OUTDOOR AIR STATIC PRESSURE SENSING TIP
A. Pressure sensor: Pressure sensing tip shall be designed to minimize the effects of wind and resulting velocity pressure up to 80 mph. Acceptable manufacturers shall be Dwyer A-306. Substitutions shall be allowed per Division 1.
B. Low Air Pressure Surge Dampener: 30-second time constant. Acceptable manufacturer shall be Modus SD030. Substitutions shall be allowed per Division 1.

2.15 CONTINUOUS LEVEL TRANSMITTERS
A. Ultrasonic Type
1. Provide a non-contacting, temperature compensating, narrow beam, ultrasonic type level transmitter with adjustable span and zero.
2. Output: 4-20 mA.
3. Transducer Materials: PC/ABS, Polypropylene, PVC and/or Teflon.
5. Approvals: UL, CE or CSA.
6. Accuracy: ±.5% of calibrated span.
7. Acceptable Manufacturers: Flowline EchoSpan, Princo Instruments, & Greyline. Substitutions shall be allowed per Division 1.
B. Capacitance Type
1. Provide a loop powered, continuous capacitance type level transmitter with adjustable span and zero.
2. Output: 4-20 mA.
3. Probe: Fluoropolymer coated stainless steel rod or cable. Provide cable probe with end attachment hardware or weight.
5. Approvals: UL or CSA.
6. Accuracy: ±1% of calibrated span.
7. Process Connection: MPT or ANSI Flange as required.
8. Acceptable Manufacturers: Drexelbrook, Endress & Hauser. Substitutions shall be allowed per Division 1.

2.16 INSERTION TYPE TURBINE METER FOR WATER SERVICE
A. Turbine Insertion Flow Meter sensing method shall be impedance sensing (iron magnetic and non-photoelectric), with volumetric accuracy of +/- 2% of reading over middle 80% of operating range, and +/- 4% of reading over the entire operating range. Turbine Insertion Flow Meter shall have maximum operating pressure of 400 psi and maximum
operating temperature of 200°F continuous (220°F peak). All wetted metal parts shall be  
constructed of 316 stainless steel. Flow meter shall meet or exceed all of the accuracy,  
head loss, flow limits, pressure and material requirements of the AWWA standard C704-70  
for the respective pipe or tube size. Analog outputs shall consist of non-interactive  
zero and span adjustments, a DC linearly of 0.1% of span, voltage output of 0-10 V, and  
current output of 4-20 mA.
1. Install in water systems with a minimum of 10 pipe diameters unobstructed flow.
2. Acceptable Manufacturers: Onicon Corp. and Hersey. Substitutions shall be  
allowed per Division 1.

2.17 FLOW METER FOR STEAM:
A. Flow Computer: KEP Supertrol II with MODBUS RTU Communication Card  
B. Maximum Fluid Temperature: 800°F (427°C)  
C. Wetted Parts: Stainless Steel  
D. Housing: NEMA 4X  
E. Turndown: 10:1 minimum.  
F. Accuracy: 1% of calibrated span  
G. Body: Wafer style or ANSI flanged to match piping specification.  
H. Acceptable Manufacturers: Veris Accelebar and Onicon Vortex. Substitutions shall be  
allowed per Division 1.

2.18 VORTEX SHEDDING FLOW METER FOR LIQUID AND GAS SERVICE:
A. Output: 4-20 mA, 0-10 Vdc, 0-5 Vdc  
B. Maximum Fluid Temperature: 800°F (427°C)  
C. Wetted Parts: Stainless Steel  
D. Housing: NEMA 4X  
E. Turndown: 10:1 minimum.  
F. Accuracy: 0.5% of calibrated span for liquids, 1% of calibrated span for gases.  
G. Body: Wafer style or ANSI flanged to match piping specification.  
Substitutions shall be allowed per Division 1.

2.19 AIRFLOW MEASURING STATIONS (AFMS)
A. Pitot Tube Grids: Provide an array of velocity pressure sensing elements with averaging  
manifolds and air straightening vanes packaged in a sheet metal casing. Distribute  
sensing elements in accordance with ASHRAE for traversing ducts. Provide taps to  
connect tubing from instrumentation. Label AFM with drawing number designation,  
design flow, velocity pressure, and pressure drop. Application of pitot grids shall be  
allowed only where minimum expected flow is greater than 30% or maximum flow  
B. Vortex Shedding Grid: Provide an array of vortex shedding elements designed to  
produce stable ‘Karmen Vortices’ that are linear with air velocity. Provide the  
electronics to totalize the pulses and output average velocity proportional to an output  
signal of 4-20ma.
1. Sensor Accuracy: ±1.5%
2. Electronics Accuracy: ±0.5%
3. Range: Select minimum range to accommodate the expected flow range of the project
4. Temperature Limits: 20-140°F
5. Acceptable Manufacturer: Tek-Air Systems Inc. ‘Vortek’ Model. Substitutions shall be allowed per Division 1.

2.20 AIR VELOCITY PRESSURE SENSORS (INSERTION TYPE)
A. Single or Multi-Point Averaging (as indicated): Sensing tip shall be for insertion into duct with mounting flange and push on tube connections. Material shall be suitable to the application.

2.21 CO₂ SENSORS/TRANSMITTERS (CO2)
A. CO₂ sensors shall use silicon based, diffusion aspirated, infrared single beam, dual-wavelength sensor.
B. Accuracy: ±36ppm at 800 ppm and 68°F.
C. Stability: 5% over 5 years.
D. Output: 4-20 mA, 0-10 Vdc or relay.
E. Mounting: Duct or Wall as indicated.
F. Acceptable Manufacturer: Vaisala, Inc. GMD20 (duct) or GMW20 (wall).

2.22 ELECTRIC CONTROL COMPONENTS
A. Limit Switches (LS): Limit switches shall be UL listed, SPDT or DPDT type, with adjustable trim arm. Limit switches shall be as manufactured by Square D, Allen Bradley. Substitutions shall be allowed per Division 1.
B. [Electric Solenoid-Operated Pneumatic Valves (EP): EP valves shall be rated for a minimum of 1.5 times their maximum operating static and differential pressure. Valves shall be ported 2-way, 3-way, or 4-way and shall be normally closed or open as required by the application. EPs shall be sized for minimum pressure drop, and shall be UL and CSA listed. Furnish and install gauges on all inputs of EPs. Furnish an adjustable air pressure regulator on input side of solenoid valves serving actuators operating at greater than 30 psig.
   1. Coil Enclosure: Indoors shall be NEMA-1, Outdoors and NEMA-3, 4, 7, 9.
   2. Fluid Temperature Rating: Valves for compressed air and cold water service shall have 150 °F (66 °C) minimum rating. Valves for hot water or steam service shall have fluid temperature rating higher than the maximum expected fluid temperature.
   3. Acceptable Manufacturers: EP valves shall be as manufactured by ASCO or Parker. Substitutions shall be allowed per Division 1.
   4. Coil Rating: EP valves shall have appropriate voltage coil rated for the application (i.e., 24 VAC, 120 VAC, 24 VDC, etc.).]
C. Low Temperature Detector (‘Freezestat’) (FZ): Low temperature detector shall consist of a ‘cold spot’ element which responds only to the lowest temperature along any one foot of entire element, minimum bulb size of 1/8” x 20’ (3.2mm x 6.1m), junction box for wiring connections and gasket to prevent air leakage or vibration noise, DPST (4 wire, 2
circuit) with manual reset. Temperature range 15 to 55°F (-9.4 to 12.8°C), factory set at 38°F.

D. Surface-Mounted Thermostat: Surface-mounted thermostat shall consist of SPDT contacts, operating temperature range of 50 to 150°F (10 to 65°C), and a minimum 10°F fixed setpoint differential.

E. Low Voltage Wall Thermostat: Wall-mounted thermostat shall consist of SPDT sealed mercury contacts, operating temperature range of 50 to 90°F (10 to 32°C), switch rating of 24 Vac (30 Vac max.), and both manual and automatic fan operation in both the heat and cool modes.

F. Control Relays: All control relays shall be UL listed, with contacts rated for the application, and mounted in minimum NEMA-1 enclosure for indoor locations, NEMA-4 for outdoor locations.

1. Control relays for use on electrical systems of 120 volts or less shall have, as a minimum, the following:
   a) AC coil pull-in voltage range of +10%, -15% or nominal voltage.
   b) Coil sealed volt-amperes (VA) not greater than four (4) VA.
   c) Silver cadmium Form C (SPDT) contacts in a dustproof enclosure, with 8 or 11 pin type plug.
   d) LED pilot light indication of power-to-coil and coil retainer clips.
   e) Coil rated for 50 and 60 Hz service.
   f) Acceptable Manufacturers: Relays shall be Potter Brumfield, Model KRPA. Substitutions shall be allowed per Division 1.

2. Relays used for across-the-line control (start/stop) of 120V motors, 1/4 HP, and 1/3 HP, shall be rated to break minimum 10 Amps inductive load. Relays shall be IDEC. Substitutions shall be allowed per Division 1.

3. Relays used for stop/start control shall have low voltage coils (30 VAC or less), and shall be provided with transient and surge suppression devices at the controller interface.


H. Control Transformers: Furnish and install control transformers as required. Control transformers shall be machine tool type, and shall be US and CSA listed. Primary and secondary sides shall be fused in accordance with the NEC. Transformer shall be proper size for application, and mounted in minimum NEMA-1 enclosure.

1. Transformers shall be manufactured by Westinghouse, Square ‘D’, or Jefferson. Substitutions shall be allowed per Division 1.

I. Time Delay Relays (TDR): TDRs shall be capable of on or off delayed functions, with adjustable timing periods, and cycle timing light. Contacts shall be rated for the application with a minimum of two (2) sets of Form C contacts, enclosed in a dustproof enclosure.

1. TDRs shall have silver cadmium contacts with a minimum life span rating of one million operations. TDRs shall have solid state, plug-in type coils with transient suppression devices.
2. TDRs shall be UL and CSA listed, Crouzet type. Substitutions shall be allowed per Division 1.

J. Electric Push Button Switch: Switch shall be momentary contact, oil tight, push button, with number of N.O. and/or N.C. contacts as required. Contacts shall be snap-action type, and rated for minimum 120 Vac operation. Switch shall be 800T type, as manufactured by Allen Bradley. Substitutions shall be allowed per Division 1.

K. Pilot Light: Panel-mounted pilot light shall be NEMA ICS 2 oil tight, transformer type, with screw terminals, push-to-test unit, LED type, rated for 120 VAC. Unit shall be 800T type, as manufactured by Allen-Bradley. Substitutions shall be allowed per Division 1.

L. Electric Selector Switch (SS): Switch shall be maintained contact, NEMA ICS 2, oil-tight selector switch with contact arrangement, as required. Contacts shall be rated for minimum 120 Vac operation. Switch shall be 800T type, as manufactured by Allen-Bradley. Substitutions shall be allowed per Division 1.

2.23 REFRIGERANT MONITOR

A. General: Contractor shall provide a refrigerant sensitive infrared-based stationary refrigerant gas leak monitor system designed to continuously measure refrigerants. Refrigerant monitor shall be coordinated to detect refrigerants used in the chiller equipment. The alarm system shall comply with ANSI/ASHRAE 15-1994 and local code requirements.

B. The refrigerant monitor shall be capable of monitoring multiple refrigerant gas compounds at multiple locations in concentrations of 0 PPM to a minimum of 1000 PPM. The Monitor shall have a low range resolution of 1 PPM in the range of 1 PPM through 100 PPM. Readings above 100 PPM must be accurate to within ±5% of reading. Accuracy shall be maintained within ambient environmental ranges of 0ºC. through 50ºC., (32ºF. through 122ºF.) and 5% through 90% relative humidity, non-condensing.

C. The refrigerant monitor shall automatically and continuously monitor the areas through a sample draw type tubular pick up system with an internal pump and filter. The installation of the monitoring control and the tubing shall be in strict accordance with the manufactures instructions. The location, routing, and final position of the sample tubes shall be submitted to the engineer with all necessary shop drawings and monitor specifications and installation instructions. Tubing size, tubing material, and tube length limitations shall be within the specifications of the monitor manufacture. The location and method of tube support and hangers must be identified on the shop drawings. Each of the sampling tubes shall have end of line filters.

D. The analyzer will be based on infrared detection technology, and will be factory tested and calibrated for the specified refrigerant or refrigerants. Factory certification of the calibrations shall be provided with the O&M manuals. The analyzer shall provide a menu driven or automatic method of checking both zero, span calibration for each sensor, and allow for adjustment.

E. The monitor shall be equipped with 4 outputs. Three relays shall energize at an adjustable user defined set point based on refrigerant concentration levels. The relay threshold adjustment shall be protected by keyed or password access controls. Adjustments and observations shall be made at the front panel operator interface. The relay threshold values can be viewed without a password. The digital display will continuously display the refrigerant concentration level and alarm status. The fourth output shall indicate a monitor malfunction alarm. The monitor shall also have an analog
output that will provide a linear scaled reference to the refrigerant concentration in parts per million. The analog output signal shall be an industry standard DC voltage, or mA current signal.

F. The monitor shall have a NEMA-4 moisture resistant enclosure with a gasketed, hinged front cover. Conduits and tube connections shall be located on the bottom of the enclosure. The enclosure shall have a rust and corrosion resistant finish.

G. The following alarm modes will be provided by the refrigerant monitor:

1. ALARM LEVEL ONE – Low level of refrigerant concentration at one of the sampling points has detected the presence of a possible refrigerant leak. The initial alarm threshold shall be set to 5 PPM (adj.) and increased if there are nuisance alarms. This alarm level shall be displayed on the refrigerant monitor interface panel, indicating which sensor has triggered the alarm, and the associated concentration of refrigerant in PPM. This event will also send an Alarm Level One signal to the BAS through a digital output from the monitor relay. This alarm will remain active until the refrigerant concentration is reduced below set point.

2. ALARM LEVEL TWO – This alarm shall indicate that one of the sensors has detected a refrigerant concentration that is approaching dangerous levels in the area being monitored. This alarm shall be set to 25% below the maximum calculated refrigerant level specified in ANSI/ASHRAE 15-1994 and ASHRAE 34-1992. This alarm will be displayed on the monitor interface, and will indicate which of the sensors has caused the alarm, and the highest concentration in PPM. This event will also activate the beacon and audible alarm mounted on the refrigerant monitoring enclosure. This alarm will also be sent to the BAS through the digital output of the relay. In this mode the audible alarm can be silenced, but the beacon shall remain active until the fault is cleared.

3. ALARM LEVEL THREE – This alarm shall be set at the maximum calculated refrigerant level specified in ANSI/ASHRAE 15-1994 and ASHRAE 34-1992 whichever is the lowest concentration. The refrigerant monitor interface will display which sensor has caused the alarm, and the associated concentration in PPM. This event will also activate the beacon and audible alarm mounted on the refrigerant monitoring enclosure. If the audible alarm had been silenced by an earlier alarm, the activation of this level three alarm will cause the audible alarm to be activated again. The relay in the refrigerant monitoring panel shall activate the space ventilation system, and will disable all combustion or flame-producing equipment via hardwired control interlocks. In addition, this event and will de-energize the energy source for any hot surface (850°F or 454°C) located in the space. Interlocks must also be provided to close any normally open doors or openings to the space for proper ventilation and isolation during this alarm condition. This alarm level will also signal the BAS through the digital output through the same relay. In this mode, the audible alarm can be silenced, but the beacon shall remain active until the fault is cleared.

H. All alarm conditions shall be report to the BAS system as follows:

1. ALARM LEVEL ONE - The lowest refrigerant alarm level shall detect the presence of refrigerant in low concentrations and energize a relay to signal a low level alarm to the BAS operator terminal(s). The alarm shall display an alarm message stating that there is a potential refrigerant leak in the designated area.

2. ALARM LEVEL TWO - The second refrigerant level alarm shall be a high refrigerant alarm alert. This alarm shall energize a relay to signal the BAS system
indicating a high level alarm on the BAS operator terminal(s). This BAS alarm shall state that high levels of refrigerant have been detected in the designated area.

3. FAULT ALARM – Reports a high level alarm to the BAS operator terminal(s) that there is a fault in the refrigerant monitoring alarm system.

2.24 NAMEPLATES
   A. Provide engraved phenolic or micarta nameplates for all equipment, components, and field devices furnished. Nameplates shall be 1/8 thick, black, with white center core, and shall be minimum 1" x 3", with minimum 1/4" high block lettering. Nameplates for devices smaller than 1" x 3" shall be attached to adjacent surface.
   B. Each nameplate shall identify the function for each device.
   C. For pump Variable Speed Drives (VSDs), provide an engraved nameplate at the VSD indicating the location of the controlling Remote Differential Pressure (RDP) transmitter(s). Location shall include the ‘Plan’ room number as well as the actual ‘Building’ room number.

2.25 TESTING EQUIPMENT
   A. Contractor shall test and calibrate all signaling circuits of all field devices to ascertain that required digital and accurate analog signals are transmitted, received, and displayed at system operator terminals, and make all repairs and recalibrations required to complete test. Contractor shall be responsible for test equipment required to perform these tests and calibrations. Test equipment used for testing and calibration of field devices shall be at least twice as accurate as respective field device (e.g., if field device is +/-0.5% accurate, test equipment shall be +/-0.25% accurate over same range).

PART 3 EXECUTION

3.01 INSPECTION
   A. Examine areas and conditions under which control systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.02 INSTALLATION OF CONTROL SYSTEMS
   A. General: Install systems and materials in accordance with manufacturer's instructions, roughing-in drawings and details shown on drawings. Install electrical components and use electrical products complying with requirements of National Electric Code and all local codes.
   B. Control Wiring: The term "control wiring" is defined to include providing of wire, conduit and miscellaneous materials as required for mounting and connection of electric control devices.
      1. Wiring System: Install complete wiring system for electric control systems. Conceal wiring except in mechanical rooms and areas where other conduit and piping are exposed. Installation of wiring shall generally follow building lines. Install in accordance with National Electrical Code and Division 16 of this Specification. Fasten flexible conductors bridging cabinets and doors, neatly along hinge side, and protect against abrasion. Tie and support conductors neatly.
2. **Control Wiring Conductors:** Install control wiring conductors, without splices between terminal points, labeled with device served. Install in neat workmanlike manner, securely fastened. Install in accordance with National Electrical Code and Division 16 of this Specification.

3. **Communication wiring shall be run in separate conduit from all other wiring.** Signal wiring and low voltage control wiring shall be installed separate from any wiring over thirty (30) volts. Signal wiring shield shall be grounded at controller end only, unless otherwise recommended by the controller manufacturer.

4. **All WAN and LAN Communication wiring shield shall be terminated as recommended by controller manufacturer.** All WAN and LAN Communication wiring shall be orange jacketed and labeled with a network number, device ID at each termination and shall correspond with the WAN and LAN system architecture and floor plan submittals.

5. **All communications wiring shall be in conduit unless pre-approved by UCB.**

6. **All low-voltage wiring external to control panels shall be in conduit, unless pre-approved.** Conduit type, sizing, and installation requirements shall conform to NEC and Division 26.

7. **Number-code or color-code conductors appropriately for future identification and servicing of control system.** Code shall be as indicated on approved installation drawings. Preferred identification system: BRADY

C. **Control Valves:** Install so that actuators, wiring, [and tubing] connections are accessible for maintenance. Where possible, install with valve stem axis vertical, with operator side up. Where vertical stem position is not possible, or would result in poor access, valves may be installed with stem horizontal. Do not install valves with stem below horizontal, or down.

D. **Freezestats:** Install freezestats in a serpentine fashion where shown on drawing. Provide one foot of element for each square foot of coil face area. Where coil face area exceeds required length of element, provide multiple devices, wired in parallel for normally open close on trip application, wired in series for normally closed, open on trip application. Adequately support with coil clips.

E. **Space Temperature Sensors:** Sensors shall be located as indicated on drawings.
   1. Mount non-adjustable sensors with centerline 60” above finished floor. Sensors with adjustable setpoints and/or override switches must be mounted 36” to 48” above finished floor; coordinate with UCB.
   2. Coordinate location of sensor with work of other trades so sensor does not conflict with or is obstructed by such items as blackboards, bleachers, bookcases, etc.
   3. Conceal all control wiring to sensors located in new finished spaces; the use of wiremold is prohibited.
   4. Thermostats located in Locker Rooms, Team Rooms, Storerooms, and Corridors shall be flush mounted type.

F. **Averaging Temperature Sensors:** Cover no more than three square feet per linear foot of sensor length except where indicated. Generally where flow is sufficiently homogeneous/adequately mixed at sensing location, consult AE for requirements.

G. **Airflow Measuring Stations:** Install per manufacturer’s recommendations in an unobstructed straight length of duct (except those installations specifically designed for
installation in fan inlet). For installations in fan inlets, provide on both inlets of double inlet fans and provide inlet cone adapter as recommended by AFM station manufacturer.

H. Fluid Flow Sensors: Install per manufacturer’s recommendations in an unobstructed straight length of pipe.

I. Relative Humidity Sensors: Provide element guard as recommended by manufacturer for high velocity installations. For high limit sensors, position remote enough to allow full moisture absorption into the air stream before reaching the sensor.

J. Differential Pressure Transmitters: Provide valve bypass arrangement to protect against over pressure damaging the transmitter.

K. Flow Switches: Where possible, install in a straight run of pipe at least 15 diameters in length to minimize false indications.

L. Phase-Voltage-Frequency Monitor: Electrical contractor shall provide and install. Control contractor shall coordinate installation of control wiring with electrical contractor.

M. Current Switches for Motor Status Monitoring: Adjust so that setpoint is below minimum operating current and above motor no load current.

N. Supply Duct Pressure Transmitters:
   1. General: Install pressure tips with at least 4 ‘round equivalent’ duct diameters of straight duct with no takeoffs upstream. Install pressure tips securely fastened with tip facing upstream in accordance with manufacturer’s installation instructions. Locate the transmitter at an accessible location to facilitate calibration.
   2. VAV System ‘Down-Duct’ Transmitters: Locate pressure tips approximately 2/3 of the hydraulic distance to the most remote terminal in the air system. UCB must approve final location.

O. Test Ports: Provide test ports in ductwork at each temperature and humidity sensor location to facilitate sensor calibration. Test ports shall be 3/4” diameter minimum and accessible via a 2” x 4” junction box with insulated cover.

P. Cutting and Patching Insulation: Repair insulation to maintain integrity of insulation and vapor barrier jacket. Use hydraulic insulating cement to fill voids and finish with material matching or compatible with adjacent jacket material.
SECTION 23 09 93
SEQUENCE OF OPERATION

PART 1 – GENERAL

1.1 DESCRIPTION OF WORK:

A. Sequence of operation is hereby defined as the manner and method by which controls function. Requirements for each type of control system operation are specified in this section.

B. Operating equipment, devices, and system components required for control systems are specified in other Division 15 Controls' sections of these specifications. This section will be added after this design development phase.

C. The sequence of operation, the control diagrams and the temperature control matrix are all binding. If there is a discrepancy between them, the worst case shall be used for bidding purposes.

PART 2 - PRODUCTS

2.1 SYSTEM REQUIREMENTS:

A. Provide control systems consisting of thermostats, control valves, dampers, operators, indicating devices, interface equipment, and other apparatus required to operate mechanical system and to perform functions specified.

B. Provide necessary materials and field work necessary to connect control components factory supplied as part of equipment controlled, unless specified otherwise. Generally, self-contained valves, filter gauges, liquid level controllers and similar instruments, are not to be installed under this section.

C. Unless specified otherwise, provide fully proportional components.

D. Provide all necessary relays and signal boosters to make the system a full and operable system as required by the sequence of operation.

PART 3 – EXECUTION

3.1 TERMINAL UNITS’ CONTROL SEQUENCES:

A. Hot Water Cabinet Unit Heaters and Unit Heaters (Temp. Unit Heaters): Provide unit mounted thermostat to automatically modulate a normally open two way control valve and cycle the fan motor to maintain the thermostat setting (75° F – Adjustable).

B. Hot Water/Chilled Water Fan Coil Units: Provide wall mounted or unistrut mounted (penthouse) thermostat to automatically modulate the control valves and cycle the fan motor to maintain the space thermostat heating (68° F-Ajustable) and cooling settings (72° F – Adjustable). For Hot Water/Chilled Water units, hot water valve shall fail open and chilled water valve shall fail closed. For ducted fan coil units, provide discharge air temperature sensor downstream of FCU for display at BAS.

C. Chilled Water Only Fan Coil Units: Provide wall mounted thermostat to automatically modulate the normally open chilled water control valve and cycle the fan motor to maintain the space thermostat cooling settings (72° F – Adjustable). For ducted fan coil units, provide discharge air temperature sensor downstream of FCU for display at BAS.
D. Vivarium Hot Water Heating Duct Coils: Provide duct mounted temperature sensor to automatically modulate a normally closed two way valve to maintain the set point (70°F – Adjustable). Temperature sensor shall be located in the exhaust duct between the room and the Phoenix box within the mezzanine space above the vivarium. Provide discharge air temperature sensor downstream of coil for display at BAS.

E. Fin Tube Radiant Heaters Above Ceiling (Freeze Protection Only): Provide unit mounted thermostat to automatically modulate a normally open two way control valve to maintain the thermostat (sense temperature in plenum space at unit) setting (45°F – Adjustable).

F. Radiant Floor Heat: 3-way T.C. valve shall provide 3 stage sequence of operation as described below: When the outdoor temperature falls below 50 deg (adj), circulator pump shall be energized and circulate full flow for the duration of its operation. When the space temperature falls below setpoint, 3-way valve shall modulate to provide 85 degree underfloor radiant supply temperature to zone manifold. 2nd stage of heat shall provide 95 degree underfloor radiant supply water temperature to the manifold. 3rd stage of heat shall provide 105 degree underfloor radiant supply water temperature to the zone manifold. When the outdoor air temperature rises above 50 degree (adj), circulator pump shall be de-energized. Provide 2 hour (adj) time delay on pump energizing to avoid excessive cycling of pumps.

3.2 TERMINAL BOX CONTROL SEQUENCES:

A. Variable Air Volume Without Reheat: The thermostat shall control the damper operator on the variable volume, pressure independent terminal box. On a drop or rise in temperature below or above set point, the thermostat shall modulate the airflow between zero and maximum scheduled air quantities to satisfy the thermostat set point.

B. Variable Air Volume with Reheat: The thermostat shall control the damper operator on the variable volume, pressure independent terminal box. On a drop in room temperature below thermostat set point, the thermostat shall modulate the airflow to zero to satisfy thermostat cooling set point. On further drop in room temperature below thermostat heating set point, the thermostat shall modulate the reheat coil normally open two-way control valve and increase the air flow to satisfy thermostat set point. On rise in temperature above the thermostat set point, the thermostat shall close the normally open two-way control valve and modulate the airflow to maximum scheduled air quantity.

C. Laboratory/Vivarium VAV with Reheat: The supply VAV boxes shall communicate with the exhaust VAV boxes to maintain a volumetric offset in order to keep the laboratory negative. The thermostat shall control the damper operator on the variable volume, pressure independent terminal box to a position not exceeding the limits of the volumetric offset of the exhaust boxes. On a drop in room temperature below thermostat set point, the thermostat shall modulate the airflow minimum scheduled air quantity to satisfy thermostat cooling set point. On further drop in room temperature below thermostat heating set point, the thermostat shall modulate the reheat coil normally closed two-way control valve to satisfy thermostat set point. The previous heating sequences shall not be enabled if the boiler plant is off line. On rise in temperature above the thermostat set point, the thermostat shall close the normally closed two-way control valve and modulate the airflow to maximum scheduled air quantity. The exhaust VAV boxes shall have a similar operation and track the supply boxes to maintain a negative volumetric offset.

D. Variable Air Volume with Reheat Interlocked with perimeter convector/finned tube heating: The temperature sensor shall control the damper operator on the variable volume, pressure independent terminal box. On a drop in temperature below cooling set point, the temperature sensor shall modulate the airflow to minimum scheduled air quantity to satisfy cooling set point. On further drop in temperature below heating set point, the temperature sensor shall modulate the perimeter heat normally...
open control valve to satisfy heating set point. If the perimeter heating valve is full open and the temperature continues to drop, the reheat valve shall modulate open and reheat the air.

E. Variable Air Volume without Reheat Interlocked with perimeter convector/finned tube heating: The temperature sensor shall control the damper operator on the variable volume, pressure independent terminal box. On a drop in temperature below cooling set point, the temperature sensor shall modulate the air flow to minimum scheduled air quantity to satisfy cooling set point. On further drop in temperature below heating set point, the temperature sensor shall modulate the airflow to zero and modulate the perimeter heat normally open control valve to satisfy heating set point.

F. VAV Box Zone, Non-Lab Demand Control Ventilation (CO2 based) – If required:

1. A CO₂ sensor shall monitor the CO₂ levels in each zone.

G. VAV Box Override Button: Labs wit the push buttons shall allow the general exhaust valve to open to full open position.

H. Parallel Fan Powered Variable Air Volume with Reheat: The thermostat shall control the damper operator on the primary air, variable volume, pressure independent terminal box. On a drop in room temperature below thermostat set point, the thermostat shall modulate the reheat coil normally open two-way control valve and increase the air flow to satisfy thermostat set point. On rise in temperature above the thermostat set point, the thermostat shall close the normally open two-way control valve and modulate the airflow to maximum scheduled air quantity. During unoccupied hours when primary air is not being delivered from the main air handling unit, the space set point shall be allowed to drift up. On a drop in room temperature below thermostat unoccupied setpoint (55 deg adj.) the terminal fan shall be enabled. On further drop in room temperature below thermostat unoccupied heating set point, the thermostat shall modulate the reheat coil normally open two-way control valve and maintain the terminal fan air flow to satisfy thermostat set point. On rise in temperature above the thermostat unoccupied set point, the thermostat shall close the normally open two-way control valve and maintain the airflow being delivered from the terminal fan. As space temperature approaches occupied set point during unoccupied hours, the terminal fan shall be disabled.

3.3 HYDRONIC HEATING:

A. Upon a call for heat, the heating plant shall enable from the BAS.

B. Boilers: The BAS shall enable and, stage the 4 condensing boilers based on the water temperature setpoint in the main. Each boiler shall have a primary pump. The primary pump shall show proof of flow prior to the boiler starting. Hot water supply temperature sensors for each boiler are to be included and connected to the Andover.

C. Above an outside air temperature of 50 deg F (adjustable), Boiler B-4 shall be the lead boiler. Boilers 1, 2 & 3 shall be lag boilers during this time.

D. Below an outside air temperature of 50 deg F (adjustable), Boilers B-1, B-2 and B-3 shall rotate as the lead boiler based on a weekly schedule so that each boiler rotates to the lead boiler every third week. Rotation shall occur on Wednesday’s at 9:00 a.m. Boiler B-4 shall be the 3rd lag boiler during this time and be allowed to operate if needed.

E. If at any time the lead boiler fails, send an alarm to the BAS and start the first lag boiler.

F. Pumps: Fully redundant secondary pumps shall operate in a lead-stand-by configuration. The lead pump shall run continuously when the plant is enabled. Should the lead pump fail as sensed by a
current switch or a status signal from the VFD, the stand-by pump shall be activated and an alarm shall be sent to the BAS. Automatic change over to occur on Wednesday’s at 9:00 a.m. The secondary pump speed shall be controlled from the differential pressure transmitter located at the most remote location.

G. On a variation in the supply water temperature of 10 degrees (adjustable) below or above the set point, an alarm shall be sent to the BAS.

H. Heating water reset schedule: The heating water supply temperature (adjustable) shall be reset as a straight line function of outside air temperature as follows:

1. O.A.T. below 0 degrees: 160 degree water temperature
2. O.A.T. above 60 degrees: 125 degree water temperature

3.4 PENTHOUSE GLYCOL HEATING SYSTEM

A. Pumps: Fully redundant pumps shall operate in a lead-stand-by configuration. The lead pump shall run continuously. Should the lead pump fail as sensed by current via the VFD, the stand-by pump shall be activated and an alarm shall be sent to the BAS. Automatic change over to occur on Wednesday’s at 9:00 a.m. If the lead pump fails, lock it out until it can be reset manually.

B. Heating water heat exchangers: Upon proof of flow, modulate the building control valve(s) to maintain the supply water temperature set point.

C. On a variation in the supply water temperature of 10 degrees (adjustable) below or above the return set point, an alarm shall be sent to the BAS.

D. Heating water reset schedule: The heating water supply temperature (adjustable) shall be reset as a straight line function of outside air temperature as follows:

1. O.A.T. below 0 degrees: 155 degree water temperature
2. O.A.T. above 50 degrees: 120 degree water temperature

E. Proof of flow is required prior to any heat exchanger control valve opening.

3.5 AIR HANDLER CONTROL SEQUENCES:

A. Office/Public Space Air Handling Units:

1. The air handling unit shall be controlled by a local DDC control panel interfaced with the Building Automation System. The system shall be complete with access through local or remote terminals.

2. The AHU shall start based on the UCB optimum start/stop sequence. Whenever air handling unit air fan is started, the minimum outside air damper shall open and the return and relief air dampers shall open to their minimum positions. The supply and return/relief fans shall cycle on through an interlock.

3. The minimum outside air damper shall modulate to maintain minimum outside air as being measured by an airflow measuring station in the O.A. duct. Modulate outside air dampers to achieve a 500 ppm differential of CO2 from O.A. to R.A. in a staged scenario so that the minimum O.A. damper is fully open before the other damper modulates. Subject to a low limit.
4. The supply fan speed shall be modulated by the duct static pressure controller through the local control panel and the variable frequency drive.

5. Provide a discharge air temperature reset schedule prior to static pressure reset. Reset the temperature up to 65°F based on VAV damper positions of 20% VAV boxes.

6. The system shall reset the duct static pressure setpoint based on the position of the most open VAV box within 20% of all VAV boxes. The duct static setpoint shall continue to reset until the most open VAV box is at 90% open. As the most open VAV box continues to open beyond the 90% mark, the duct static setpoint shall begin to move up to compensate for the critical box.

7. The return fan speed shall be modulated through the local control panel and variable frequency drive to maintain a fixed (adjustable) return air duct static pressure.

8. Relief air dampers shall be modulated to maintain the building at (+) 0.02 in-wc (adjustable) through static pressure sensors.
   a. Coordinate with test and balance contractor to optimize the offset to provide for proper building pressurization.

9. Airside Economizer: Below an outside air temperature of 55°F (adjustable), the outside air, return air and relief air dampers shall modulate to maintain a 55°F (adjustable) mixed air set point. Refer to the reset sequence for change in setpoint.

10. Above an outside air temperature greater than the temperature of the return air, the dampers shall be set at minimum outside air conditions. This shall operate in parallel to the CO₂ monitoring.

11. The system preheat coil will be controlled to maintain a coil discharge temperatures as scheduled on the drawings. The preheat coil recirculating pump will run when outside air temperature is below 40deg F. (adjustable). Hand-off auto switches will provide manual override of the pump if needed. Green indicating pilot light will indicate the run status of the pump.

12. Chilled water cooling is to be locked out while evap cooling is in operation. When the supply air temperature rises to above 55°F. (adjustable), the chilled water pressure independent control valve shall modulate to meet set point. A pressure transducer around the Delta-P valve shall report system pressure to BAS for pump speed control.

13. When the air temperature downstream of the preheat coil is 40°F send an alarm. At freeze stat trip (35 degrees), the supply and return air fans shall shut down through a hard-wire interlock, the outside air and exhaust air dampers shall close 100% return air dampers should fail open, the chilled water coil pump shall enable and an alarm shall be sent to the BAS. Upon manual reset the unit shall return to normal operation.

14. On detection of smoke from the unit mounted smoke detectors or on signal from the fire alarm system, the supply and return fans shall cycle off through a hard wire interlock and the outside air, return air and exhaust air dampers shall close, all associated fire/smoke dampers shall close and an alarm shall be sent to the BAS. Upon manual reset at the fire alarm panel, the unit shall return to normal operation.

15. On detection of high or low static pressure in the supply air or return air ductwork, the supply and return fans shall cycle off through a hard wire interlock, the outside air and exhaust air dampers shall close 100% the return air damper shall open 100% and an alarm shall be sent to BAS. Upon manual reset the unit shall return to normal operation.
16. Filter Status Monitoring: Differential pressure transmitter shall be provided across each of the air handling unit filter stages, the pre-filter and the final filter. Analog signals shall be sent to the BAS.

17. Pre-heat Coil: Below an outside air temperature of 50° F (adjustable), the preheat coil pump shall cycle on and the two way normally closed control valve modulate to maintain 50° F (adjustable). Provide current sensor for status point.

18. Cooling Coil: The chilled water cooling coil shall be locked out while evap cooling is in operation. When the discharge air temperature rises above 60° F (adjustable), the normally closed two-way cooling coil control valve shall open and modulate to maintain 60° F (adjustable).
   a. The heating and cooling control valves shall not operate simultaneously.
   b. Cooling shall be locked out below 55 degree (adjustable) outside air temperature.
   c. The cooling coil shall be interlocked with evaporative cooling so they do not operate simultaneously.

19. Evaporative Cooling:
   a. Open the outside air dampers full open.
   b. When the supply air temperature rises above 55deg F, the evaporative cooling sump pumps within the unit shall be staged sequentially as follows: 1)center section  2)center and side sections 3)all 3 sections. If the supply air temperature continues to rise to 60deg F (adj.) when all 3 stages of evaporative cooling enabled, the normally closed two-way chilled water cooling coil control valve shall open and modulate to maintain 55° F (adjustable) DAT. The cooling coil shall be interlocked with evaporative cooling so they do not operate simultaneously.
   c. A return air % RH sensor shall be provided to disable evaporative cooling above 40% RH (adj.). Evaporative cooling shall be re-enabled once the return %RH drops to 35% (adj.). Discharge air %RH shall be used for monitoring only.
   d. Evaporative cooling media dry-out cycle: The evaporative cooling media shall be dried out each night by disabling the sump pumps for 1 hour, if the evaporative pumps had run during the previous 24 hours.
   e. Evaporative cooling sump drain down cycle: Once a week, drain the sump and continue to run the fans for 1 hour to dry the media and sump, if the evaporative cooling system had been used in the previous 7 day period (Adj.).
   f. Evaporative cooling freeze protection: Drain down of the evaporative cooling sump shall occur if the OA temperature drops below 40 deg F (adj.). Re-fill the sump upon a call for the 1st stage of cooling.
   g. Sump pumps shall not start until sump is full of water.

20. If the discharge air temperature rises above 60 degrees, then the direct evap is to turn off. O.A. dampers go to minimum position and start the cooling control sequence after a 5 minute (adj.) delay.

B. Server Room Air Handling Units
1. The air handling unit shall be controlled by a local DDC control panel interfaced with the Building Automation System. The system shall be complete with access through local or remote terminals.

2. The AHU shall start based on the UCB optimum start/stop sequence. Whenever air handling unit air fan is started, the minimum outside air damper shall open and the return and relief air dampers shall open to their minimum positions. The supply fan shall cycle on through an interlock.

3. The minimum outside air damper shall modulate to maintain minimum outside air as being measured by an airflow measuring station in the O.A. duct. Modulate outside air dampers to achieve a 500 ppm differential of CO2 from O.A. to R.A. in a staged scenario so that the minimum O.A. damper is fully open before the other damper modulates.

4. The supply fan speed shall be modulated by the duct static pressure controller through the local control panel and the variable frequency drive.

5. Airside Economizer: Below an outside air temperature of 55°F (adjustable), the outside air, return air and relief air dampers shall modulate to maintain a 55°F (adjustable) mixed air set point.

6. Above an outside air temperature greater than the temperature of the return air, the dampers shall be set at minimum outside air conditions. This shall operate in parallel to the CO2 monitoring.

7. The system preheat coil will be controlled to maintain a coil discharge temperatures as scheduled on the drawings. The preheat coil recirculating pump will run when outside air temperature is below 40deg F. (adjustable). Hand-off auto switches will provide manual override of the pump if needed. Green indicating pilot light will indicate the run status of the pump.

8. Chilled water cooling is to be locked out while evap cooling is in operation. When the supply air temperature rises to above 55°F. (adjustable), the chilled water pressure independent control valve shall modulate to meet set point. A pressure transducer around the Delta-P valve shall report system pressure to BAS for pump speed control.

9. When the air temperature downstream of the preheat coil is 40°F send an alarm. At freeze stat trip (35 degrees), the supply and return air fans shall shut down through a hard-wire interlock, the outside air and exhaust air dampers shall close 100%, the chilled water coil pump shall enable and an alarm shall be sent to the BAS. Upon manual reset the unit shall return to normal operation.

10. On detection of smoke from the unit mounted smoke detectors or on signal from the fire alarm system, the supply and return fans shall cycle off through a hard wire interlock and the outside air, return air and exhaust air dampers shall close, all associated fire/smoke dampers shall close and an alarm shall be sent to the BAS. Upon manual reset at the fire alarm panel, the unit shall return to normal operation.

11. On detection of high or low static pressure in the supply air or return air ductwork, the supply and return fans shall cycle off through a hard wire interlock, the outside air and exhaust air dampers shall close 100% the return air damper shall open 100% and an alarm shall be sent to BAS. Upon manual reset the unit shall return to normal operation.

12. Filter Status Monitoring: Differential pressure transmitter shall be provided across each of the air handling unit filter stages, the pre-filter and the final filter. Analog signals shall be sent to the BAS.
13. Pre-heat Coil: Below an outside air temperature of 50°F (adjustable), the preheat coil pump shall cycle on and the two way normally closed control valve modulate to maintain 50°F (adjustable). Provide current sensor for status point.

14. Cooling Coil: The chilled water cooling coil shall be locked out while evap cooling is in operation. When the discharge air temperature rises above 60°F (adjustable), the normally closed two-way cooling coil control valve shall open and modulate to maintain 60°F (adjustable).
   a. The heating and cooling control valves shall not operate simultaneously.
   b. Cooling shall be locked out below 55 degree (adjustable) outside air temperature.
   c. The cooling coil shall be interlocked with evaporative cooling so they do not operate simultaneously.

15. Evaporative Cooling:
   a. Open the outside air dampers full open.
   b. When the supply air temperature rises above 55 deg F, the evaporative cooling sump pumps within the unit shall be staged sequentially as follows: 1) center section 2) center and side sections 3) all 3 sections. If the supply air temperature continues to rise to 60 deg F (adj.) when all 3 stages of evaporative cooling enabled, the normally open two-way chilled water cooling coil control valve shall open and modulate to maintain 55°F (adjustable) DAT. The cooling coil shall be interlocked with evaporative cooling so they do not operate simultaneously.
   c. A return air % RH sensor shall be provided to disable evaporative cooling above 40% RH (adj.). Evaporative cooling shall be re-enabled once the return %RH drops to 35% (adj.). Discharge air %RH shall be used for monitoring only.
   d. Evaporative cooling media dry-out cycle: The evaporative cooling media shall be dried out each night by disabling the sump pumps for 1 hour, if the evaporative pumps had run during the previous 24 hours.
   e. Evaporative cooling sump drain down cycle: Once a week, drain the sump and continue to run the fans for 1 hour to dry the media and sump, if the evaporative cooling system had been used in the previous 7 day period (Adj.).
   f. Evaporative cooling freeze protection: Drain down of the evaporative cooling sump shall occur if the OA temperature drops below 40 deg F (adj.). Re-fill the sump upon a call for the 1st stage of cooling.
   g. Sump pumps shall not start until sump is full of water.

16. If the discharge air temperature rises above 60 degrees, then the direct evap is to turn off. O.A. dampers go to minimum position and start the cooling control sequence after a 5 minute (adj.) delay.

C. Main Laboratory Air Handling Units

1. Whenever the supply fans are activated, the associated supply and outside air dampers shall be opened. Dampers shall be normally closed.
2. The supply fan(s) shall not enable until proof of flow (current switch or VFD status) from the associated exhaust fans and proof of open dampers as sensed by end switches.

3. The AHU’s shall operate in a lead/lag parallel configuration; however it is anticipated both will normally operate together in parallel. The AHU fans shall modulate speed to maintain static pressure set point. If the lead AHU is the only unit enable and if fans of the lead AHU is at 50% (adj.) the lag AHU shall enable with fan at min speed then the damper shall open. Upon signal from end switch the fan shall increase and modulate speed to maintain set point. When both AHU’s are on, they shall equally control to the same static set point so that all VFD’s are operating at the same speed. When both AHU’s drop below 25% speed (adj), disable the lag AHU.

4. As the load decreases and both AHU’s are operating, if all VFD’s are operating at or less than 25% (adj.), disable the lag AHU. The lag AHU shall be disabled for a minimum of 15 minutes (adj) before re-start.

5. Provide a discharge air temperature reset schedule prior to static pressure reset. Reset the temperature up to 65°F based on VAV damper positions of 20% of all VAV boxes.

6. The system shall reset the duct static pressure setpoint based on the position of the most open VAV box within 20% of all VAV boxes. The duct static setpoint shall continue to reset until the most open VAV box is at 90% open. As the most open VAV box continues to open beyond the 90% mark, the duct static setpoint shall begin to move up to compensate for the critical box.

7. The supply fan variable frequency drive (VFD) shall modulate the fan speed to maintain the static pressure set point measured by a pressure sensor located approximately the farthest distance of the main supply duct upstream of the farthest VAV box. A separate static pressure sensor shall be provided for each AHU, including redundant air handlers.

8. When the air temperature downstream of the preheat coil is 40°F send an alarm. At freeze stat trip (35 degrees), the supply and return air fans shall shut down through a hard-wire interlock, the outside air and exhaust air dampers shall close 100% the chilled water coil pump shall enable and an alarm shall be sent to the BAS. Upon manual reset the unit shall return to normal operation.

9. Should both air handlers go off line, the respective laboratory exhaust air fans shall be reset to exhaust 30% total airflow volume (adjustable) to maintain negative space pressure and safe hood operation. The final setting of airflow shall be coordinated with T&B contractor to insure the doors will be able to open per ADA. A signal shall be sent to Phoenix controls for this emergency condition to allow the valves to change to the emergency position.

10. Coil Controls:
   a. Heat Reclaim Coil: The three way N.O. control valve shall modulate to maintain 50°F (adjustable) air temperature downstream of the coil. An override feature shall close the valve and by-pass the water, refer also to the heat reclaim sequences.
   b. Pre-heat Coil: Below an outside air temperature of 50°F (adjustable), the preheat coil pump shall cycle on and the two way normally closed control valve modulate to maintain 50°F (adjustable). Provide current sensor for status point.
   c. Cooling Coil: The chilled water cooling coil shall be locked out while evap cooling is in operation. When the discharge air temperature rises above 60°F (adjustable), the normally open two-way cooling coil control valve shall open and modulate to maintain 60°F (adjustable).
d. The heating and cooling control valves shall not operate simultaneously.

e. Cooling shall be locked out below 55 degree (adjustable) outside air temperature.

f. The cooling coil shall be allowed to operate simultaneously with evaporative cooling.

g. Evaporative Cooling:

1) When the supply air temperature rises above 55deg F, the evaporative cooling sump pumps within the unit shall be staged sequentially as follows: 1) center section 2) center and side sections 3) all 3 sections. If the supply air temperature continues to rise to 60deg F (adj.) when all 3 stages of evaporative cooling enabled, the normally open two-way chilled water cooling coil control valve shall open and modulate to maintain 55° F (adjustable) DAT. For the 100% O.A. lab units, evaporative cooling and chilled water cooling are allowed to operate simultaneously.

2) A space % RH sensor shall be provided on every floor of each neighborhood in the hallway between the laboratory suites to disable evaporative cooling above 50%RH (adj.). Evaporative cooling shall be re-enabled once the space %RH drops to 40%(adj.).

3) Evaporative cooling media dry-out cycle: The evaporative cooling media shall be dried out each night by disabling the sump pumps for 1 hour, if the evaporative pumps had run during the previous 24 hours.

4) Evaporative cooling sump drain down cycle: Once a week, drain the sump and continue to run the fans for 1 hour to dry the media and sump, if the evaporative cooling system had been used in the previous 7 day period.

5) Evaporative cooling freeze protection: Drain down of the evaporative cooling sump shall occur if the OA temperature drops below 40 deg F (adj.). Re-fill the sump upon a call for the 1st stage of cooling.

6) Sump pumps shall not start until sump is full of water. The Andover system shall us a 15 minute (adj) delay to enable pumps after the sump is full.

7) Provide alarms for pump failure.

11. On detection of smoke from the unit mounted smoke detectors or on signal from the fire alarm system, the supply fans shall cycle off through a hard wire interlock and the outside air and supply air dampers shall close, all associated fire/smoke dampers shall close via hard wire to fire alarm system and an alarm shall be sent to the BAS. Upon manual reset the unit shall return to normal operation.

12. On detection of high static pressure in the supply air ductwork, the supply fans shall cycle off through a hard wire interlock, the outside air and supply air dampers shall close 100% and an alarm shall be sent to BAS. Upon manual reset the unit shall return to normal operation.

13. Filter Status Monitoring: Differential pressure transmitter shall be provided across each of the air handling unit filter stages, the pre-filter and the final filter. Analog signals shall be sent to the BAS.

D. Stand-Alone Vivarium Air Handling Unit AHU-5
1. Whenever the supply fan is activated, the associated motorized dampers shall be opened. The fan shall not start until proof of open damper. Dampers shall be normally closed. The supply fan(s) shall not enable until proof of flow from the associated exhaust fan.

2. Should both exhaust fans serving the Vivarium suite fail, an alarm shall be sent to the BAS, AHU shall be disabled.

3. The supply fan variable frequency drive (VFD) shall modulate the fan speed to maintain the static pressure set point measured by a pressure sensor located at the farthest VAV box.

4. When the air temperature downstream of the preheat coil is 40°F, send an alarm. At freeze stat trip, the supply fan(s) shall shut down through a hard wire interlock, the outside air and discharge air dampers shall close 100% the chilled water coil pump enable and an alarm shall be sent to the BAS. Upon manual reset the unit shall return to normal operation.

5. Coil Controls:
   a. Heat Reclaim Coil: The three way N.O. control valve shall modulate to maintain 50 deg air temperature downstream of the heat recovery coil. An override feature shall close the valve and by-pass the water, refer also to the heat reclaim sequences.
   b. Pre-heat Coil: Below an outside air temperature of 50° F (adjustable), the preheat coil pump shall cycle on and the two way normally closed control valve modulate to maintain 55° F (adjustable) discharge air temperature.
   c. Cooling Coil: When the discharge air temperature rises above 58° F (adjustable), the normally open two-way cooling coil control valve shall open and modulate to maintain 55° F (adjustable). If the AHU is controlled off, the valve shall close. Normally open applies to power failure, not AHU being controlled off.
   d. The heating and cooling control valves shall not operate simultaneously.
   e. Cooling shall be locked out below 55 degree (adjustable) outside air temperature.
   f. The cooling coil and evaporative cooling shall be allowed to operate simultaneously.
   g. Evaporative Cooling:
      1) When the supply air temperature rises above 55deg F, the evaporative cooling sump pumps within the unit shall be staged sequentially as follows: 1)center section 2)center and side sections 3) all 3 sections. If the supply air temperature continues to rise to 58deg F (adj.) while all 3 stages of evaporative cooling is enabled, the normally open two-way chilled water cooling coil control valve shall open and modulate to maintain 55° F (adjustable) DAT. For the 100% O.A. lab/vivarium units, evaporative cooling and chilled water cooling are allowed to operate simultaneously.
      2) A space % RH sensor shall be provided to disable evaporative cooling above 50%RH (adj.). Evaporative cooling shall be re-enabled once the space %RH drops to 40%(adj.).
      3) Evaporative cooling media dry-out cycle: The evaporative cooling media shall be dried out each night by disabling the sump pumps for 1 hour, if the evaporative pumps had run during the previous 24 hours.
4) Evaporative cooling sump drain down cycle: Once a week, drain the sump and continue to run the fans for 1 hour to dry the media and sump, if the evaporative cooling system had been used in the previous 7 day period.

5) Evaporative cooling freeze protection: Drain down of the evaporative cooling sump shall occur if the OA temperature drops below 40 deg F (adj.). Re-fill the sump upon a call for the 1st stage of cooling.

6) Sump pumps shall not start until sump is full of water. The Andover system shall us a 15 minute (adj) delay to enable pumps after the sump is full.

7) Provide alarms for pump failure.

6. On detection of smoke from the unit mounted smoke detectors or on signal from the fire alarm system, the supply fans shall cycle off through a hard wire interlock and the outside air, and supply air dampers shall close, all associated fire/smoke dampers shall close via a hard wire interlock with the fire alarm system and an alarm shall be sent to the BAS. Upon manual reset the unit shall return to normal operation.

7. On detection of high static pressure in the supply air ductwork, the supply fans shall cycle off through a hard wire interlock, the supply air dampers shall close 100% and an alarm shall be sent to BAS. Upon manual reset the unit shall return to normal operation.

8. Filter Status Monitoring: Differential pressure transmitter shall be provided across each of the air handling unit filter stages, the pre-filter and the final filter. Analog signals shall be sent to the BAS.

9. If the air handling units fail the supply air and outside air damper shall close and the normally open bypass damper over to the adjacent laboratory air handling unit shall open and an alarm sent to the BAS. Upon this cross over damper opening, priority shall be given to the animal holding rooms in the Vivarium. All VAV boxes on the lab system and non-animal holding rooms shall reduce position to not allow any more than 75% open position (adj.) for the Phoenix valves.

3.6 EXHAUST FANS:

A. Parallel (partial redundant) Exhaust Fans: Partial Redundant exhaust fans shall operate in parallel Lead-Lag-Lag mode to deliver the total amount of airflow scheduled with associated isolation dampers open. Switch Lead/Lag every Wednesday at 5 a.m.

1. The exhaust fans shall communicate status with the associated air handlers. Status shall be ascertained from both the VFD current and the duct static pressure.

2. Should one fan fail or be disabled, the other exhaust fans shall ramp up to full speed to attempt to control to the static pressure set point, and an alarm sent to the BAS. If the static pressure falls below 0.5”(adj.), it shall be considered a fan failure.

3. Lab Neighborhoods: It is the intent with 3 fans each sized for 40% of the load that at a minimum 2 fans would need to operate to meet the load. If the system needs, all 3 fans could operate simultaneously. Upon start up of a lag fan, the lead fan shall ramp down as the lag fan ramps up so that both then control to maintain set point.

4. Tissue Culture Suite (3rd C Wing): It is the intent with 2 fans each sized for 60% of the load that both fans need to operate to meet the load.
5. The exhaust fans shall start at the minimum speed and the associated dampers shall open after 5 seconds (adj.). Upon proof of damper being open, begin modulating fan speed.

6. Each fan shall be controlled by a VFD. The VFD shall adjust the speed of the fan to maintain the duct static pressure set point as sensed by a pressure sensor located at the farthest VAV box. The fans shall all control to the same static pressure setpoint. A second static pressure sensor shall be installed at the same location to act as a back-up if the primary signal becomes unreliable. Where fans are outside the building and VFD inside, provide wiring between the local disconnect to the VFD to disable VFD when disconnect is switched off.

7. The system shall reset the duct static pressure setpoint based on the position of the most open VAV box within 20% of all VAV boxes. The duct static setpoint shall continue to reset until the most open VAV box is at 90% open. As the most open VAV box continues to open beyond the 90% mark, the duct static setpoint shall begin to move up to compensate for the critical box.

8. Upon failure of a specific fan, the inlet damper shall close, an alarm sent to BAS and a signal sent to the Phoenix control system to reset the maximum position on the associated general (non-hood) VAV boxes to 80%. If two of the three fans fail, an alarm shall be sent to the Phoenix control system to BAS and a signal sent to reset the maximum position on the associated general (non-hood) VAV boxes to 40% (adj.).

9. Upon failure of both associated air handling units, the fans shall ramp down to 30% total airflow (adjustable) to maintain space negative pressure while allowing doors to open. The final setting of airflow shall be coordinated with T&B contractor to insure the doors will be able to open per ADA. Also a signal shall be sent to the Phoenix control system to reset all non-hood exhaust VAV boxes to ensure hoods are kept safe.

B. Parallel (fully redundant) Exhaust Fans (Vivarium): Fully Redundant exhaust fans shall operate in Lead-Standby mode to deliver the total amount of airflow scheduled with associated isolation dampers open.

1. The exhaust fans shall communicate status with the associated air handlers. Status shall be ascertained from both VFD run status and duct static pressure.

2. The lead exhaust fan shall be enabled at all times. Should the lead fan fail or be disabled, the standby exhaust fan shall enable and ramp up to meet the static pressure set point, and an alarm sent to the BAS.

3. The Lead fan shall be switched on a monthly (adjustable) schedule for the 1st Wednesday of each month at 5:00 a.m. During this switchover, the stand-by fan shall enable and ramp up as the lead fan ramps down to maintain the pressure cascade. The lag fan shall enable to begin rotation in proper direction prior to opening the damper to ensure the wheel does not spin backwards.

4. The exhaust fans shall not ramp up beyond minimum speed until the associated dampers prove to be open as sensed by end switches.

5. Each fan shall be controlled by a VFD. The VFD shall adjust the speed of the fan to maintain the duct static pressure set point as sensed by a pressure sensor located at the farthest (worst hydraulic location) VAV box. Where fans are outside the building and VFD inside, provide wiring between the local disconnect to the VFD to disable VFD when disconnect is switched off.

6. Upon failure of both fans, the dampers shall close, alarm sent to BAS and an alarm sent to the BAS.
C. Stand-alone exhaust fans with VFD:
   1. The exhaust fan shall be enabled at all times. Fans shall not enable until proof of open isolation dampers.
   2. The fan shall be controlled by a VFD. The VFD shall adjust the speed of the fan to maintain the duct static pressure set point as sensed by a pressure sensor located the farthest distance down the duct.
   3. Upon failure of the fan, the dampers shall close, alarm sent to BAS and a signal sent to shut down the associated air handling unit serving that suite.
   4. Upon failure of the associated air handling unit the fan shall ramp down to 30% (adjustable) to maintain space negative pressure while allowing doors to open. The final setting of airflow shall be coordinated with T&B contractor to insure the doors will be able to open per ADA.

D. Stand-alone exhaust fans without VFD’s:
   1. Exhaust fan shall operate at all times with on/off control through the BAS.
   2. Upon failure of the fan, an alarm shall be sent to BAS.

E. Welding Hood exhaust fan:
   1. Exhaust fan shall operate manually from a wall switch adjacent to the hood. The BAS shall monitor status and provide an output signal to the associated Phoenix valve for that room to command the valve to set back to the reset value.

3.7 STEAM BOILER PLANT SEQUENCE:
   A. The boiler shall receive an enable signal from the Building Automation System.
   B. The DDC system shall sense the steam pressure in the steam header with a pressure sensor. The steam set point shall be 80 psi (adjustable). If the boiler is operating at 100% and the pressure drops below 70 psi (adjustable) for 10 minutes (adjustable), send an alarm to the BAS.
   C. The boiler(s) internal controls shall modulate the burner capacity to maintain the 80 psi (adjustable) set point.
   D. The boiler internal controls shall include modulating water level controls. These level controls shall provide a start/stop command to the deaerator pump control panel. The deaerator pump control panel shall then enable the lead feed water pump anytime the boiler is enabled. Modulate the feed water control valve to maintain the water level in the boiler. Verify the pumps have the bypass to the tank installed to avoid dead-head condition when the make-up closes. Wiring between the boilers and packaged deaerator will need to be accomplished by this contractor and coordinated with the boiler/deaerator supplier.
   E. If the burner of a boiler fails, a general boiler alarm shall be sent to the BAS.
   F. If the level of the boiler drops below the minimum setting (still above low-water cut-out) a “LOW WATER” boiler alarm shall be sent to the BAS.
G. Upon failure of a boiler feed pump, the associated boiler shall be deactivated and a “GENERAL DEAERATOR ALARM” alarm shall be sent to the BAS. The standby feed water pump shall be enabled.

3.8 CHILLER PLANT CONTROL SEQUENCES:

A. Building Water Chillers:

1. The DDC system will operate the chilled water pumps on a lead/lag sequence, off of an owner-defined schedule. Once the lead pump has proven flow through a flow switch (from the chiller), the chilled water system will go under control. The DDC system will modulate the lead pump’s VFD to maintain chilled water differential pressure set point as sensed by chilled water differential pressure sensors located across all of the Delta-P valves. If the lead pump does not prove flow, an alarm will be sent to the BAS and the lag standby pump will be started and controlled as stated above.

2. The DDC system will operate the condenser water pumps on a lead/lag sequence, off of an owner-defined schedule. Once the lead pump has proven flow, the condenser water system will go under control. If the lead pump does not prove flow through a flow switch from the chiller, an alarm will be sent to the BAS and the lag pump will be started and controlled as stated above.
   a. When switching from flat plate control back to mechanical cooling the 3-way bypass valve shall modulate to warm up the condenser water by bypassing the cooling tower and slowly sending water to the tower to maintain the setpoint. Coordinate with chiller manufacturer to receive this signal from the chiller.
   b. During switch over, shut off the chilled water pump and the condenser water pumps. Shut pumps off before switchover occurs for shutdown. Once contact is made with the switches open pumps to be enabled.

3. The DDC system will operate the chillers on a lead/lag sequence, based off of an owner-defined schedule (Once a month on Wednesday’s 5 a.m.). Once the chilled water pumps and condenser water pumps have proven flow, the lead chiller will initiate its start-up program. The lead chillers isolation valves shall open prior to the pump being enabled. Once the chiller control package senses chilled water and condenser water flows, it will start and maintain chilled water discharge temperature set point.
   a. When the lead chiller reaches 100% capacity for 15 minutes (adjustable) and the water temperature exceeds the setpoint by 2°F (adj.), lag condenser water pump shall start, lag chiller’s isolation valves open and the lag cooling tower will be energized once the pump has proven flow. Once the lag chiller-control package senses chilled water and condenser water flows, it will start and maintain chilled water discharge temperature set point, along with the lead chiller.
   b. When both chillers reduce down to 50% capacity (adj) for 15 minutes (adjustable) and/or the water temperature drops 2°F (adj.) below setpoint, the lag chiller will be de-energized. After sufficient time is allowed for the lag chiller to coast down, the lag chiller’s isolation valves close and the condenser water pump will be de-energized.
   c. When the chilled water flow drops to within 2% of the chiller manufacturers recommended minimum flow rate, as determined by a flow meter, the chilled water bypass valve shall begin to modulate open maintaining this volume as the system minimum. As the chilled water flow rate begins to increase above 5% of the minimum flow rate the by-pass valve shall begin to modulate to the closed position. Only one chiller shall operate when chilled water is in the bypass mode.
4. Waterside Economizer Cooling: Below 50 deg F. (adj.) outside air temperature (adjustable), the flat plate heat exchanger will provide cooling to the building. If the lead cooling towers are operating at 100% and the chilled water supply temperature rises 4 deg F (adjustable) above set point, the system will switch over to mechanical cooling. Mechanical cooling can also be enabled manually through the BAS. Provide appropriate time delays 1 hour (adj.) to prevent excessive cycling from free cooling to mechanical cooling.

5. Flat Plate Heat Exchanger Control: When the chilled water system is in waterside economizer operation, the BAS will slowly open the heat exchanger’s isolation valves. The chillers will be de-energized and their isolation valves are slowly closed. The reverse happens when mechanical cooling is enabled. During the switch over between mechanical cooling and flat plate cooling, the associated chilled water and condenser water pumps shall be disabled.

6. If the Emergency Power-Off Break Glass Switch, located at the chiller room’s exit doors, is activated the BAS will perform a controlled shutdown of the chiller room equipment, according to the chiller manufacturer’s recommendations and send an alarm to the BAS.

7. The DDC system shall interface with the chillers on-board control panels.

8. The process cooling heat exchanger and pump shall be energized at all times to circulate water to the building. The automatic isolation valves shall be opened prior to enabling the pump. The PWCS temperature sensor shall be used to modulate the chilled water control valve. The VFD for the pump shall modulate to maintain system pressure based on Delta-P valves as sequenced in the chilled water system.

B. Condenser Water System:

1. Condenser Water Pump Control: The DDC system will operate the condenser water pumps on a lead/lag sequence, off of an owner-defined schedule (Wednesday’s at 5 a.m.). Once the lead pump has proven flow, the condenser water system will go under control. If the lead pump does not prove flow, an alarm will be sent to the BAS and the lag pump will be started and controlled as stated above.

2. Condenser Water Control: The DDC system will operate the cooling tower cells on a lead/lag sequence, off of an owner-defined schedule. The lead cell’s isolation valve will open, allowing condenser water to flow to the tower.

3. The DDC system will modulate the cooling tower fan’s VFD’s to maintain condenser water supply temperature according to the following adjustable reset schedule: 75 deg F LWT @ 67 deg F WB to 55 deg F LWT @ 45 deg F WB during mechanical cooling.

4. If the condenser water temperature is 5 degrees (adjustable) above set point and the lead cooling tower’s fan is at 90% speed for 15 minutes (adjustable), the lag-cooling tower will be energized. The lag tower’s isolation valve open, and the lag tower fan will cycle, along with the lead tower’s fan, to maintain condenser water supply temperature set point.

5. When the condenser water temperature is 5 degrees (adjustable) below set point and both tower fans are at 30% (adjustable) to manufacture’s suggested low limit speed) speed for 5 minutes (adjustable), the lag-cooling tower’s fan will be de-energized and its isolation valves will close.

6. Condenser Water Temperature Control – Waterside Economizer: The BAS will reset the condenser water supply temperature to maintain 45deg F. (adjustable) chilled water supply temperature during free cooling. Tower fans will operate as above to maintain this setpoint.
7. Cold Weather Operation: When outdoor air temperature is below 34deg F. (adjustable) and the lag tower is off, the BAS will first close the lag cooling tower isolation valves. With the lead tower operating, the bypass valve shall modulate to maintain the condenser water temperature setpoint. The sump heaters in each tower shall operate to keep the water in the sumps at 40° F (adj.). The sump heaters shall not operate when the sump is empty.

8. Cooling Tower Level Controls: The BAS will monitor the cooling tower basin levels and control the make-up water valve to maintain the water level in the cooling tower.

9. Cooling Tower Safeties: Stop cooling tower fan and alarm the BAS if the vibration switch senses excessive vibration.

3.9 CHILLER ROOM VENTILATION SEQUENCE OF OPERATIONS:

A. The chiller room exhaust fans shall be controlled through a local DDC panel interfaced with the BAS.

B. The BAS shall enable the exhaust fans and monitor run status. Exhaust fan EF-7B shall run continuously. Exhaust fan EF-7A shall enable based on the refrigerant monitoring system detecting refrigerant or when the break glass EPO button is depressed.

C. Exhaust Fan EF-7A for Emergency Ventilation Purge. The BAS will monitor fan status. Fan operational status will be indicated on the chiller room, ventilation panel with two yellow lamps labeled “Emergency Ventilation Run” and “Emergency Ventilation Off.” Also on the face of the panel is an “Emergency Ventilation” On-Auto switch, controlling the exhaust fan, or allowing the refrigerant leak detection panel to control the exhaust fan.

D. If the refrigerant leak detection panel detects the PEL level for the specific refrigerant in the chiller room, a blue rotating lamp on top of the ventilation panel will illuminate, and an alarm horn on the face of the ventilation panel will sound. An alarm will be sent to the BAS.

E. The following conditions will switch the exhaust fan on and send an alarm to the BAS:
   a. Emergency Ventilation switch to “ON” at the Chiller Room, ventilation panel.
   b. Refrigerant leak detection panel detects 50% of the IDHL level for the specific refrigerant in the chiller room.
   c. Closure of an Emergency Ventilation Break glass Switch.

F. If the Emergency Power-Off Break Glass Switch, located at the chiller room’s exit doors, is activated, the BAS will perform a controlled shutdown of the chiller room equipment, according to the chiller manufacturer’s recommendations, and send an alarm to the BAS.

3.10 HYDRONIC HEAT RECLAIM SYSTEM (RUN-AROUND LOOP):

A. The purpose of this system is to reclaim both heating and cooling energy depending on the time of year. In the winter, warm exhaust air heats the system and in turn heats the incoming air. In the summer, the exhaust air cools the system and in turn cools the incoming air.

B. System Circulating Pumps: Circulating pumps shall be activated as a function of outside air temperature. If the outside air temperature is below 55° F or above 80° F (adjustable), the circulating pump shall be activated. Should the lead pump fail as sensed by a current relay, the standby pump shall enable and an alarm shall be sent to the BAS. Rotate the Lead pump every Wednesday at 5 a.m.

C. The air temperature sensor used for the preheat control valves, located in AHU shall also control the three-way, modulating bypass valve at each air handling unit to maintain air temperature of 55° F during winter months when O.A. temperature is below 50° F and to achieve best possible temperature during summer when O.A. temperature is above 80° F.
D. A water temperature sensor shall be utilized so that when it reads a temperature of 35° F or lower (adjustable), the 3-way control valves modulate and bypass the air handling unit coils to keep frost from forming on the exhaust coils. This bypass shall be to gradually bypass the air handler and NOT a two position type control. During this condition, the valve shall control to 35 degrees instead of air temperature and shall return to air temperature control after the water temperature rises above 35 degrees while the 3-way valve is at full open to the coil.

3.11 HEAT HARVESTER HEAT RECLAIM SYSTEM CONTROL:

A. The heat harvester shall operate anytime there is the need for simultaneous heating and cooling in the building. This shall be determined by polling the heating valves to insure there is a call for heat and by the chiller status.

B. The heat harvester will operate on its own controls to achieve the best temperature differential for both heating water and chilled water.

C. Motorized butterfly valves in the main lines shall modulate to maintain minimum flow through the heat harvester as measured by insertion type turbine flow meters.

D. The heat harvester shall report status and alarms to the BAS.

E. **Motorized butterfly isolation valves shall close any time the heat harvester is disabled to keep water from flowing through the machine.**

F. **When the heat harvester is enabled, and the heating water return temperature entering the heat harvester exceeds 135 deg F (adjustable), disable the heat harvester and send an alarm to the BAS.**

3.12 DOMESTIC/INDUSTRIAL HOT WATER HEATERS CONTROL:

A. The indirect water heaters shall operate from their own factory controls to modulate the internal pump speed to achieve set point.

B. The BAS shall modulate a heating water control valve to regulate the heating buffer tank to 125 deg F.

C. The BAS shall monitor the hot water supply temperature leaving the indirect water heaters and provide alarms if the set point of 120 deg F (adj.) is not maintained. Alarm if temperature exceeds 130 deg F.

3.13 MISCELLANEOUS CONTROL SEQUENCES:

A. Emergency Power Equipment Start-Up: Coordinate with the electrical contractor and the emergency generator supplier to provide a status signal to the BAS from each generator. Sequenced start-up of mechanical equipment shall be provided in the following order:

   **NOTE – Priority has changed.**

   1. Control system (Andover, Phoenix and Encilium all provided with UPS’s)
   2. Vivarium exhaust fans
   3. Heating system (pumps, boilers)
   4. Glycol heating pumps and AHU heating circulation pumps
   5. Vivarium Air handling units
   6. Laboratory exhaust fans (1A, 1B, 2A, 2B, 3A, 3B, 4A, 4B, 5, 7A, 7B, 9A)
   7. AHU Supply fans (1A, 2A, 3A, 4A, 5, 8A, 8B)
   8. Cooling system
   9. Steam Boiler and DA
   10. **NOTE: If AHU-5 fails during Emergency power mode, start AHU-1B.**
B. If in the emergency power mode and the systems cannot maintain supply or exhaust static pressure, send EM Mode to Phoenix Controls to set back the matching pairs of non-hood air valves to 75%.

C. Room pressure monitors: Status and alarms shall be monitored from these panels through the BAS. An adjustable time delay shall be used prior to sending an alarm to account for door opening/closing time.

D. Glycol Feeder Alarms shall indicate failure and/or low water. Glycol feeders will control from their own packaged controls based on system pressure.

E. Provide interface with building lighting controls.

F. Obtain status/alarms from the following equipment:

   1. Sump Pumps
   2. Air compressors
   3. Vacuum Pumps
   4. DI Water Skids
   5. Sand Filter
   6. Deaerator

G. Servery Transfer Fan (EF-11) Stand-Along Fan without VFD Sequence of Operation:
Exhaust fan shall be normally disabled with on/off control, and fan status indication through the BAS. Upon detection of elevated temperatures - 100 deg (adj.) at the upper level of the servery space, the fan shall be enabled. Exhaust fan shall be disabled upon upper level temperature falling below 90 deg (adj.) Upon failure of fan, an alarm shall be sent to the BAS.

END OF SECTION 23 09 93
SECTION 23 11 23
NATURAL GAS SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. This Section includes distribution piping systems for natural gas and manufactured gas within the building and extending from the point of delivery to the connections with gas utilization devices. Piping materials and equipment specified in this section include:

1. Pipes, fittings, and specialties.
2. Special duty valves.

B. This Section does not apply to LP-gas piping; industrial gas applications using such gases as acetylene and acetylenic compounds, hydrogen, ammonia, carbon monoxide, oxygen and nitrogen; gas piping, meters, gas pressure regulators and other appurtenances used by the serving gas supplier in distribution of gas.

C. Gas pressures for systems specified in this section are limited to 5 psig.

D. Products installed but not furnished under this Section include gas meters which will be provided by the utility company, to the site, ready for installation.

E. Related Sections: The following Sections contain requirements that relate to this Section:

1. Refer to Division 2 for fuel gas service piping, trenching and backfilling which is underground, outside the building, and connecting the "Gas Distribution Piping" to public utilities (or connecting groups of buildings on the same site).

2. Refer to other Division 23 sections for materials and methods for trenching and backfilling; installation of gas piping; sealing pipe penetrations through basement walls; fire and smoke barriers; piping and fittings; and mechanical identification of gas piping systems inside and outside the building.

1.2 DEFINITIONS:

A. Pipe sizes used in this Specification are Nominal Pipe Size (NPS).

B. Gas Distribution Piping: A pipe within the building which conveys gas from the point of delivery to the points of usage.

C. Gas Service Piping: The pipe from the gas main or other source of supply including the meter, regulating valve, or service valve to the gas distribution system of the building served.

D. Point of Delivery is the outlet of the service meter assembly, or the outlet of the service regulator (service shutoff valve when no meter is provided).

1.3 SUBMITTALS:

A. Product data for each gas piping specialty and special duty valve. Include rated capacities of selected models, furnished specialties and accessories, and installation instructions.

B. Shop drawings detailing dimensions, required clearances, for connection to gas meter.
C. Record Drawings: At project closeout, submit record drawings of installed systems products; in accordance with requirements of Division 23.

D. Maintenance data for gas specialties and special duty valves, for inclusion in operating and maintenance manual specified in Division 23.

E. Welders' qualification certificates, certifying that welders comply with the quality requirements specified under "Quality Assurance" below.

F. Test reports specified in Part 3 below.

1.4 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of natural gas systems products, of types, materials, sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Installer Qualifications: Installation and replacement of gas piping, gas utilization equipment or accessories, and repair and servicing of equipment shall be performed only by a qualified installer. The term qualified is defined as experienced in such work (experienced shall mean having a minimum of 5 previous projects similar in size and scope to this project), familiar with precautions required, and has complied with the requirements of the authority having jurisdiction. Upon request, submit evidence of such qualifications to the Architect.

C. Qualifications for Welding Processes and Operators: Comply with the requirements of ASME Boiler and Pressure Vessel Code, "Welding and Brazing Qualification."

D. Regulatory Requirements: Comply with the requirements of the following codes:

E. NFPA 54 (ANSI Z223.1) - National Fuel Gas Code, for gas piping materials and components, gas piping installations, and inspection, testing, and purging of gas piping systems.

F. Local Building Code.

G. Utility Compliance: Fabricate and install natural gas systems in accordance with local gas utility company.

H. UMC Compliance: Fabricate and install natural gas systems in accordance with IAPMO "Uniform Mechanical Code."


J. NSI B31.2 - Fuel Gas Piping.

1.5 DELIVERY, STORAGE, AND HANDLING:

A. Handling Flammable Liquids: Remove and legally dispose of liquid from a drips in existing gas piping and handle cautiously to avoid spillage or ignition. Notify the gas supplier. Handle flammable liquids used by the installer with proper precautions, and do not leave on the premises from the end of one working day to the beginning of the next.

1.6 SEQUENCING AND SCHEDULING:

A. Notification of Interruption of Service: Except in the case of an emergency, notify all affected users when the gas supply is to be turned off.
B. Work Interruptions: When interruptions in work occur while repairs or alterations are being made to an existing piping system, leave the system in safe condition.

C. Coordinate the installation of pipe sleeves for foundation wall penetrations.

1.7 EXTRA MATERIALS:

A. Valve Wrenches: Furnish to Owner, with receipt, 2 valve wrenches for each type of gas valve installed, requiring same.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Manufacturer: Subject to compliance with requirements, provide products by one of the following:

1. Gas Cocks:
   a. Crane
   b. Hammond
   c. Peter Healy
   d. Alternate: Milwaukee “Butterball” Valves
   e. Alternate: Jomar Ball Valves

2. Interior Concealed Non-Accessible and Air Plenums:
   a. All pipe and fittings shall be welded.
   b. No gas piping may be installed in air plenums per the IFGC.
   c. Refer to Section 23 21 13 for installation requirements.

3. Gas Solenoid Valves:
   a. Automatic Switch Company (ASCO)
   b. Valve Cabinets
   c. Croker
   d. Flex Connectors
   e. Thermo Tech. Co.
   f. Quick Couplers
   g. Hanson

2.2 PIPE, TUBING AND JOINTING MATERIALS:

A. Provide pipes and pipe fitting complying with Division 23.

2.3 NATURAL GAS PIPING SPECIALTIES:

A. Gas Meters: Diaphragm-type, positive displacement gas meters with aluminum cases, temperature compensated, with internal corrosion-resistant components; threaded ends for 2 inch and smaller, flanged ends for 2-1/2 inch and larger; for gas working pressures, specific gravity, and volume flow indicated.

B. Protective Coating: Provide factory applied polyethylene tape, having the following properties:
   1. Overall thickness; 20 mils.
2. Synthetic adhesive.
3. Water vapor transmission rate.
4. Gallons per 100 square inch: 0.10 or less.
5. Water absorption, percent: 0.02 or less.
6. Prime pipe and fittings with a compatible primer prior to application of tape.
7. Pipe wrapping shall conform to the following schedule:

<table>
<thead>
<tr>
<th>Pipe Size</th>
<th>Tape Width</th>
<th>Scotchwrap No.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Standard</td>
<td>Cold</td>
</tr>
<tr>
<td>1/4 - 3/4 inch</td>
<td>1 inch</td>
<td>50</td>
</tr>
<tr>
<td>1 - 1-1/2 inch</td>
<td>2 or 4 inch</td>
<td>50</td>
</tr>
<tr>
<td>2 inch and larger</td>
<td>4 inch</td>
<td>50</td>
</tr>
<tr>
<td>Color backing</td>
<td></td>
<td>Black, Green</td>
</tr>
</tbody>
</table>

C. During application of wrap, if the ambient temperature is 40°F or less, use only Scotchwrap No. 40 tape. If ambient temperature is 40°F or more, use only Scotchwrap No. 50.

D. Flexible Connectors: Thermo Tech Co. corrugated type 304 stainless steel flexible pipe with stainless steel braid and heavy flexible armor shield. Flexible connectors shall be of length for complete cleaning under and around gas appliance.

E. Provide at each end of flexible connector Hanson Gas Mate 2-way shut-off couplers and plugs.

F. Valve cabinets: For gas safety valves, No. 4 stainless steel finish, fully recessed, Series S construction, style K stainless steel door with key lock, 4 keys per cabinet, all cabinets keyed alike. Croker Model 9100

G. Modify cabinets for 6" maximum depth for valve sizes 1/2" to 1-1/2", and 8" maximum depth for valve sizes 2" to 3". Label cabinet.

H. Provide plug valve at service connection or equipment branch and quick coupler at service end of flexible hose connector. Provide union connection on appliance.

2.4 VALVES:

A. Special duty valves are specified in this section by their generic name. Refer to Part 3, "VALVE APPLICATION," for specific uses and applications for valve specified.

B. Gas Cocks ½" through 1": 100 psi WOG, bronze body, straightaway pattern, square head, threaded ends. Peter Healy 1500-F.

C. Gas Cocks 1-1/4 Inch and Larger: See lubricated plug valves, Section 15100.

D. Solenoid Valves: Aluminum body, 115 psi rated, 120 volts AC, 60 Hz, Class B continuous duty molded coil; NEMA 4 coil enclosure; electrically opened/electrically closed; dual coils; normally closed; UL and FM approved and labeled, by Automatic Switch Co. (ASCO).

E. Gas Line Pressure Regulators: Single stage, steel jacketed, corrosion-resistant gas pressure regulators; with atmospheric vent, elevation compensator; with threaded ends for 2 inch and smaller, flanged ends for 2-1/2 inch and larger; for inlet and outlet gas pressures, specific gravity, and volume flow indicated.
F. Gas Safety Valves: Gas safety valve latched open when energized, free handle design, manual reset, and a visual position indicator.

PART 3 - EXECUTION

3.1 INSPECTION:
A. General: Examine areas and conditions under which natural gas systems materials and products are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to the Installer.

3.2 PREPARATION:
A. Precautions: Before turning off the gas to the premises, or section of piping, turn off all equipment valves. Perform a leakage test as specified in "FIELD QUALITY CONTROL" below, to determine that all equipment is turned off in the piping section to be affected.

B. Conform with the requirements in NFPA 54, for the prevention of accidental ignition.

3.3 INSTALLATION OF PIPE:
A. Install natural gas piping in accordance with Division 22/23.

B. All gas piping throughout the building shall be welded.

C. Conform to the requirements of NFPA 54 - National Fuel Gas Code.

D. Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate the general location and arrangement of piping systems. Design locations and arrangements of piping take into consideration pipe sizing, flow direction, slope of pipe, expansion, and other design considerations. So far as practical, install piping as indicated.

E. Concealed Locations: Except as specified below, install concealed gas piping in an air-tight conduit constructed of Schedule 40, seamless black steel with welded joints. Vent conduit to the outside and terminate with a screened vent cap.

F. Above-Ceiling Locations: Gas piping may be installed in accessible above-ceiling spaces (subject to the approval of the authority having jurisdiction), whether or not such spaces are used as a plenum. Valves shall not be located in such spaces.

G. In Floors: Piping installed in floors shall have protective wrapping specified in PART 2 above. Piping cast in concrete slabs shall be surrounded with a minimum of 1-1/2 inches of concrete and shall not be in physical contact with other metallic structures such as reinforcing rods or electrically neutral conductors. Piping shall not be embedded in concrete slabs containing quick-set additives or cinder aggregate.

H. Piping In Partitions: Concealed piping shall not be located in solid partitions. Tubing shall not be run inside hollow walls or partitions unless protected against physical damage. This does not apply to tubing passing through walls or partitions.

I. Prohibited Locations: Do not install gas piping in or through a plenum, circulating air duct, clothes chute, chimney or gas vent, ventilating duct, dumb waiter or elevator shaft. This does not apply to accessible above-ceiling space specified above.
J. Install pipe sleeve and seals at foundation and basement wall penetrations, as specified in Division 23 Section 23.

K. Seal pipe penetrations of fire barriers using fire barrier penetration sealers specified in Division 23.

L. Drips and Sediment Traps: Install a drip leg at points where condensate may collect, at the outlet of the gas meter, and in a location readily accessible to permit cleaning and emptying. Do not install drips where condensate is likely to freeze.

M. Construct drips and sediment traps using a tee fitting with the bottom outlet plugged or capped. Use a minimum of 3 pipe diameters in length for the drip leg. Use same size pipe for drip leg as the connected pipe.

N. Use fittings for all changes in direction and all branch connections.

O. Install gas piping at a uniform grade upward to risers, and from the risers to the meter, or service regulator when meter is not provided, or the equipment.

P. Connect branch outlet pipes from the top of horizontal lines, not from the bottom or sides.

Q. Where joints are welded, soldered, or brazed and are exposed to view or cleaning - buff joints to smooth cleanable surface in accordance with NSF.

3.4 NATURAL GAS PIPING SPECIALTIES:

A. Gas Meters:

1. Install gas meter in accordance with local Utility company's installation instructions, and comply with requirements.

2. Set meter on concrete pad as indicated.

B. Protective Coating:

1. Provide protective coating on piping and fittings that will be in contact with material or atmosphere exerting a corrosive action, or piping buried in floors. Protective coating shall be applied at the factory.

C. Flexible Connectors:

1. Provide flexible connectors with full size quick coupler for all kitchen and heavy moveable gas appliance equipment.

2. Connectors shall be of lengths required to displace equipment for complete cleaning under and around gas appliance.

D. Quick Couplers:

1. Provide quick coupler at service end of flexible connectors.

E. Valve Cabinets:

1. Provide valve cabinets for gas safety valves, mounted 5' - 0" from floor to centerline. Control panels must be mounted to be visible from entry door of room or area within which panels are mounted.
3.5 **VALVE APPLICATIONS:**

A. General: The Drawings indicate valve types, locations, and arrangements.

B. Shut-off duty: Use gas cocks.

3.6 **VALVE INSTALLATIONS:**

A. Install valves in accessible locations, protected from physical damage. Tag valves with a metal tag attached with a metal chain indicating the piping systems supplied.

B. Install a gas cock upstream of each gas pressure regulator. Where two gas pressure regulators are installed in series in a single gas line, a manual valve is not required at the second regulator.

C. Install pressure relief or pressure limiting devices so they can be readily operated to determine if the valve is free; so they can be tested to determine the pressure at which they will operate; and examined for leakage when in the closed position. Pipe atmospheric vent to outdoors.

D. Solenoid valves shall be mounted with the solenoid in the vertical upright position only.

E. Electrical wiring for solenoid valves is specified in Division 26. Coordinate electrical requirements and connections.

F. Valves shall be installed with unions or other means to facilitate removal or repair without disassembly of connecting piping.

G. Gas Safety Valves:
   1. Install gas safety valves in wall boxes or exposed as shown.
   2. Coordinate electrical requirements with Division 26 contractor. Provide neoprene grommets for all piping and electrical conduit entering and existing cabinets.

3.7 **TERMINAL EQUIPMENT CONNECTIONS:**

A. Install gas cock upstream and within 6 feet of gas appliance. Install a union or flanged connection downstream from the gas cock to permit removal of controls.

B. Sediment Traps: Install a tee fitting with the bottom outlet plugged or capped as close to the inlet of the gas appliance as practical. Drip leg shall be a minimum of 3 pipe diameters in length.

C. Flexible Hose Gas Connectors: For use connecting to vibrating equipment; corrugated Type 304 stainless steel flexible pipe with stainless steel braid.

3.8 **ELECTRICAL BONDING AND GROUNDING:**

A. Install above ground portions of gas piping systems, upstream from equipment shutoff valves electrically continuous and bonded to a grounding electrode in accordance with NFPA 70 - "National Electrical Code."

B. Do not use gas piping as a grounding electrode.

C. Conform to NFPA 70 - "National Electrical Code," for electrical connections between wiring and electrically operated control devices.
3.9 **FIELD QUALITY CONTROL:**

A. Piping Tests: Inspect, test, and purge natural gas systems in accordance with NFPA 54, and local utility requirements.

B. Test system before covering underground lines.

C. Submit written results of tests to Architect.

3.10 **SPARE PARTS:**

A. Valve Wrenches: Furnish to Owner, with receipt, 2 valve wrenches for each type of gas valve installed, requiring same.

**END OF SECTION 23 11 23**
PART 1 - GENERAL

1.1 SUBMITTALS:

A. Refer to Division 1 and Basic Mechanical Requirements for administrative and procedural requirements for submittals.

B. Product Data: Submit industry standards and manufacturer's technical product data, installation instructions, and dimensioned drawings for each type of pipe and pipe fitting. Submit piping schedule showing pipe or tube weight, fitting type, and joint type for each piping system.

C. Welding Certifications: Submit reports as required for piping work.

D. Brazing Certifications: Submit reports as required for piping work.

E. Refer to 22 14 23 Piping Specialties for additional products used in hydronic piping systems.

1.2 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacturer of pipes and pipe fittings of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Welder's Qualifications: All welders shall be qualified in accordance with ASME Boiler and Pressure Vessel Code, Section IX, Welding and Brazing Qualifications.

C. Welding procedures and testing shall comply with the latest revisions of the applicable sections for B31, of the ANSI/ASME standard codes for pressure piping, noted as follows: B31.2 - Fuel Gas Piping Code.

D. Before any welding is performed, the contractor shall submit to the Architect, a copy of the Manufacturer's Record of Welder or Welding Operator Qualification Tests and his Welding Procedure Specification together with the Procedure Qualification Record as required by ASME Boiler and Pressure Vessel Code.

E. Each manufacturer or contractor shall be responsible for the quality of welding done by his organization and shall repair or replace any work not in accordance with these specifications.

F. Soldering and Brazing procedures shall conform to ANSI Standard Safety Code for Mechanical Refrigeration.

G. The University requires all plumbing work be performed under the direct supervision of licensed plumbers (4-year), with a ratio of not more than two apprentices per journeyman. The requirement also applies to licensed pipe fitters. Steam fitters need a City and County of Denver Journeyman Steam Fitters certification.
PART 2 PRODUCTS

2.1 GENERAL:

A. Piping Materials: Provide pipe and tube of type, pressure and temperature ratings, capacities, joint type, grade, size and weight (wall thickness or Class) indicated for each service. Where type, grade or class is not indicated, provide proper selection as determined by Installer for installation requirements, and comply with governing regulations and industry standards.

B. Pipe/Tube Fittings: Provide factory-fabricated fittings of type, materials, grade, class and pressure rating indicated for each service and pipe size. Provide sizes and types matching pipe, tube, valve or equipment connection in each case. Where not otherwise indicated, comply with governing regulations and industry standards for selections, and with pipe manufacturer's recommendations where applicable.

2.2 STEEL PIPES AND PIPE FITTINGS:

A. Black Steel Pipe: ASTM A 53, Grade B, type E, electric resistance welded.

B. Galvanized Steel Pipe: ASTM A 53, Grade B.

C. Seamless Steel Pipe: ASTM A 53, Grade B, type S or A106 high temperature.

D. Cast-Iron Flanged Fittings: ANSI/ASME B16.1, including bolting (Class 125 and 250).


F. Malleable-Iron Threaded Fittings: ANSI/ASME B16.3; plain or galvanized as indicated (Class 125 and 300).

G. Malleable-Iron Threaded Unions: ANSI B16.39, Class 150, 250 or 300; selected by Installer for proper piping fabrication and service requirements, including style, end connections, and metal-to-metal seats (iron, bronze or brass); plain or galvanized as indicated (Class 150, 250 and 300).


I. Steel Flanges/Fittings: ANSI/ASME B16.5, ASTM A234 (Fire Protection) including bolting and gasketing of the following material group, end connection and facing, except as otherwise indicated.

   Material Group: Group 1.1.
   End Connections: Buttwelding.
   Facings: Raised-face.

J. Steel Pipe Flanges for Waterworks Service: AWWA C207 (water service piping only).

K. Corrosion-Resistant Cast Flanges/Fittings: MSS SP-51, including bolting and gasketing (threaded where pressure is not critical).

L. Forged-Steel Socket-Welding and Threaded Fittings: ANSI B16.11, except MSS SP-79 for threaded reducer inserts; rated to match schedule of connected pipe (up to 4 inch pipe size).

M. Wrought-Steel Buttwelding Fittings: ANSI B16.9, except ANSI B16.28 for short-radius elbows and returns; rated to match connected pipe.
N. Pipe Nipples: Fabricated from same pipe as used for connected pipe; except do not use less than Schedule 80 pipe where length remaining unthreaded is less than 1-1/2 inches, and where pipe size is less than 1-1/2 inches, and do not thread nipples full length (no close-nipples).

2.3 COPPER TUBE AND FITTINGS:

A. Copper Tube: ASTM B 88; Type K or L as indicated for each service; hard-drawn temper, except as otherwise indicated.

B. ACR Copper Tube: ASTM B 280.


D. Wrought-Copper Solder-Joint Fittings: ANSI B16.22.

E. Cast-Copper Solder-Joint Drainage Fittings: ANSI B16.23 (drainage and vent with DWV or tube).

F. Wrought-Copper Solder-Joint Drainage Fittings: ANSI B16.29.


H. Bronze Pipe Flanges/Fittings: ANSI B16.24 (Class 150 and 300).

I. Copper-Tube Unions: Provide standard products recommended by manufacturer for use in service indicated.

2.4 MISCELLANEOUS PIPING MATERIALS/PRODUCTS:

A. Welding Materials: Except as otherwise indicated, provide welding materials as determined by Installer to comply with installation requirements.


B. Soldering Materials: All soldering materials shall be lead free and antimony-free.

   1. Melting Range 450-470 degrees F. All-state “Aquasafe” or equal.


   3. Flux: All flux shall be lead free, water soluble, and compatible with the solder and the materials being joined. ASTM B813-93.

C. Brazing Materials: Except as otherwise indicated, provide brazing materials to comply with installation requirements.

   1. Comply with AWSA 5.8, Section II, ASME Boiler and Pressure Vessel Code for brazing filler metal materials.

      a. Copper phosphorus -Bcup-5, 15 percent solver content, melting range 1190 to 1480 degrees F.

      b. Silver - BAg-36, 45 percent silver, cadmium-free. Melting range 1195 to 1265 degrees F.

D. Gaskets for Flanged Joints: ANSI B16.21; full-faced for cast-iron flanges; raised-face for steel flanges, unless otherwise indicated.
E. Piping Connectors for Dissimilar Non-Pressure Pipe: Elastomeric annular ring insert, or elastomeric flexible coupling secured at each end with stainless steel clamps, sized for exact fit to pipe ends and subject to approval by plumbing code.

1. Manufacturer: Subject to compliance with requirements, provide piping connectors of the following:
   a. Husky Technologies (Husky SD 4000):

F. Pipe Thread Sealant Material: Except as otherwise indicated, provide all pipe threads with the sealant material as recommended by the manufacturer for the service.

1. Manufacturer: Subject to compliance with requirements, provide piping thread sealant material of the following:
   a. The Rectorseal Corporation

G. Dielectric Waterway:

1. General: Zinc electroplated nipple with non-metallic lining for use in service indicated, which effectively isolate ferrous from non-ferrous piping (electrical conductance), prevent galvanic action and stop corrosion. Union style not acceptable. Shall conform to ASA B16.8, plated as applicable a minimum of .0005” and have no flow restrictions when assembled.

2. Manufacturers:
   a. Perfection Corp.
   c. Perfection Corp.
   d. Rockford-Eclipse Div.

PART 3 EXECUTION

3.1 EXAMINATION:

A. Verify all dimensions by field measurements. Verify that all water distribution piping may be installed in accordance with pertinent codes and regulations, and original design, and the referenced standards.

B. Examine rough-in requirements for plumbing fixtures and other equipment having water connections to verify actual locations of piping connections prior to installation.

C. Do not proceed until unsatisfactory conditions have been corrected.

3.2 PIPING INSTALLATION:

A. General: Install pipes and pipe fittings in accordance with recognized industry practices which will achieve permanently-leakproof piping systems, capable of performing each indicated service without piping failure. Install each run with minimum joints and couplings, but with adequate and accessible unions for disassembly and maintenance/replacement of valves and equipment. Reduce sizes (where indicated) by use of reducing fittings. Align piping accurately at connections, within 1/16 inch misalignment tolerance.

1. Comply with ANSI B31 Code for Pressure Piping.
2. Electrical Equipment Spaces: Do not run piping through transformer vaults and other electrical or electronic equipment spaces and enclosures. Only piping serving this type of equipment space shall be allowed.

3. Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate the general location and arrangement of piping systems. Locations and arrangements of piping take into consideration pipe sizing and friction loss, expansion, pump sizing, and other design considerations. So far as practical, install piping as indicated.

4. Use fittings for all changes in direction and all branch connections.

5. Install piping at right angles or parallel to building walls. Diagonal runs are not permitted, unless expressly indicated.

6. Conceal all pipe installations in walls, pipe chases, utility spaces, above ceilings, below grade or floors, unless indicated to be exposed to view.

7. Install piping tight to slabs, beams, joists, columns, walls, and other permanent elements of the building. Provide space to permit insulation applications, with 1 inch clearance outside the insulation. Allow sufficient space above removable ceiling panels to allow for panel removal.

8. Locate groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

9. Install drains in pressure pipe systems at all low points in mains, risers, and branch lines consisting of a tee fitting, ¾ inch ball valve, and short ¾ inch threaded end nipple and cap with chain.

10. Install piping free of sags or bends and with ample space between piping to permit proper insulation applications.

11. Fire and Smoke Wall Penetrations: Where pipes pass through fire and smoke rated walls, partitions, ceilings, and floors, maintain the fire and smoke rated integrity.

12. Exterior Wall Penetrations: Seal pipe penetrations through exterior walls using sleeves and mechanical sleeve seals. Pipe sleeves smaller than 6 inch shall be steel; pipe sleeves 6 inches and larger shall be sheet metal.

13. Floor Penetrations:
   a. Install sleeves 2” A.F.F. for all penetrations in rooms with floor drains and for all penetrations in walls surrounding the rooms.
   b. Kitchens and Mechanical Rooms – extend 4” A.F.F.
   c. All other areas where piping is exposed, extend ¼” A.F.F.
   d. All existing floors that are core drilled shall comply with a, b and c of this section.

14. Anchor piping to ensure proper direction of expansion and contraction.

15. Coordinate foundation and all other structural penetrations with structural engineer.

16. All underground piping shall be surrounded by 6” of squeegee.
B. Hydronic Piping:

1. Make reductions in hydronic pipe sizes using eccentric reducer fitting installed with the level side up.

2. Install hydronic piping branch connections to mains using Tee fittings in main with take-off out the bottom of the main, except for up-feed risers which shall have take-off out the top of the main line. Install all hydronic piping level with manual air vent at all high points in direction of flow.

3. Install hydronic piping level except for gravity flow systems such as condenser water and condensate drain piping.

C. Condensate Drain Piping:

1. Condensate drain piping from air conditioning unit coil condensate drain pan shall be of the sizes shown on the drawings.

3.3 PIPING SYSTEM JOINTS:

A. General: Provide joints of type indicated in each piping system.

B. Thread pipe in accordance with ANSI B2.1; cut threads full and clean using sharp dies. Ream threaded ends to remove burrs and restore full inside diameter. Apply pipe joint compound, or pipe joint tape (Teflon) where recommended by pipe/fitting manufacturer, on male threads at each joint and tighten joint to leave not more than 3 threads exposed.

C. Copper 2”and Larger: Braze copper tube-and-fitting joints in accordance with ASME B31.

D. Copper < 2”: Solder copper tube-and-fitting joints with silver solder. Cut tube ends squarely, ream to full inside diameter, and clean outside of tube ends and inside of fittings. Apply solder flux to joint areas of both tubes and fittings. Insert tube full depth into fitting, and solder in manner which will draw solder full depth and circumference of joint. Wipe excess solder from joint before it hardens.

E. Weld pipe joints in accordance with ASME Code for Pressure Piping, B31. Provide weld-o-let fittings for two pipe sizes less than main pipe size.

F. Weld pipe joints in accordance with recognized industry practice and as follows:

1. Weld pipe joints only when ambient temperature is above 0 degrees F (-18 degrees C) where possible.

2. Bevel pipe ends at a 37.5 degrees angle where possible, smooth rough cuts, and clean to remove slag, metal particles and dirt.

3. Use pipe clamps or tack-weld joints with 1 inch long welds; 4 welds for pipe sizes to 10 inches, 8 welds for pipe sizes 12 inch to 20 inch.

4. Build up welds with stringer-bead pass, followed by hot pass, followed by cover or filler pass. Eliminate valleys at center and edges of each weld. Weld by procedures which will ensure elimination of unsound or unfused metal, cracks, oxidation, blow-holes and non-metallic inclusions.

5. Do not weld-out piping system imperfections by tack-welding procedures; refabricate to comply with requirements.
G. Weld pipe joints of steel water pipe in accordance with AWWA C206.

H. Flanged Joints: Match flanges within piping system, and at connections with valves and equipment. Clean flange faces and install gaskets. Tighten bolts to provide uniform compression of gaskets.

3.4 PIPING APPLICATION:

A. Heating Water, Chilled Water and Condenser Water Piping:

1. 2 Inches and Smaller:
   a. Type L copper, hard drawn copper wrought copper or bronze fittings.
   b. Schedule 40 steel, threaded joints.

2. 2-1/2 Inches and Larger:
   a. Schedule 40, seamless or ERW (std. weight 12 inches and over) black steel with flanged or welded joints.
   b. Fittings: Standard weight, seamless steel, butt weld type.
   c. Flanges: 150 lb. forged steel slip-on or welding neck type.
   d. Bolting: Regular square head machine bolts with heavy hexagonal nuts.
   e. Gaskets: Thickness, material and type suitable for fluid to be handled, and design temperature and pressures.

B. Equipment Drains and Overflows:

1. Type "L" copper.

C. Sump Pump Discharge:

1. Type L, seamless, hard drawn copper tube with ANSI/ASME B16.22 wrought copper or bronze solder-joint pressure fittings.

3.5 EXPOSED PIPING IN FINISHED AREAS:

A. Plumbing piping and fittings which are exposed (and uninsulated) in finished areas generally occupied by people including, but not limited to, kitchens, animal cagewash/equipment washing rooms, autoclave or sterilizing rooms shall be installed with a smooth, high polish, durable chrome plated finish.

3.6 PIPING TESTS:

A. General: Provide temporary equipment for testing, including pump and gauges. Test piping system before insulation is installed wherever feasible, and remove control devices before testing. Test each section of each piping system independently but do not use piping system valves to isolate sections where test pressure exceeds valve pressure rating. Fill each section with water and pressurize for indicated pressure and time.

B. Test all piping systems as specified. Correct leaks by remaking joints. Remove equipment not able to withstand test procedure during test.
C. Work to be installed shall remain uncovered until the required tests have been completed.

D. Piping which is to be concealed shall be tested before being permanently enclosed.

E. As soon as work has been completed, conduct preliminary tests to ascertain compliance with specified requirements. Make repairs or replacements as required.

F. Give a minimum of twenty-four hours notice to Engineer of dates when acceptance test will be conducted. Conduct tests as specified for each system in presence of representative of owner, agency having jurisdiction or his representative. Submit three (3) copies of successful tests to the Engineer for his review. Report shall state system tested and date of successful test.

G. Contractor shall obtain certificates of approval, acceptance and compliance with regulations of agencies having jurisdiction. Work shall not be considered complete until such certificates have been delivered by the Engineer to the Owner.

H. All costs involved in these tests shall be borne by Contractor.

I. System Tests

1. Hydrostatic Test: The test shall be accomplished by hand pumping the system to the specified water pressure, and maintaining that pressure until the entire system has been inspected for leaks, but in no case for a time period of less than four hours.
   a. Heating water: 100 psig or 150 percent of operating pressure, whichever is greater.
   b. Chilled water: 100 psig or 150 percent of system pressure, whichever is greater.
   c. Condenser water: 100 psig or 150 percent of system pressure, whichever is greater.

2. Compressed Air or Nitrogen Test: Compressed air tests may be substituted for hydrostatic tests only when ambient conditions prohibit safe use of hydrostatic testing and must be reviewed by the Engineer prior to any testing. For tests of this type, the piping system shall be subjected to the gas pressure indicated for that specific system. The piping capped or plugged and water-pumped with oil free air, or a nitrogen bottle shall be introduced into the entire system to the pressure specified. The system shall maintain that pressure for the duration of a soapy water test of each joint.

3. Repair piping systems sections which fail required piping test, by disassembly and re-installation, using new materials to extent required to overcome leakage. Do not use chemicals, stop-leak compounds, mastics, or other temporary repair methods.

4. Drain test water from piping systems after testing and repair work has been completed.

3.7 ADJUSTING AND CLEANING:

A. General: Clean exterior surfaces of installed piping systems of superfluous materials, and prepare for application of specified coatings (if any). Flush out piping systems with clean water before proceeding with required tests. Inspect each run of each system for completion of joints, supports and accessory items.

1. Inspect pressure piping in accordance with procedures of ASME B31.

B. Clean and flush hydronic piping systems. Remove, clean, and replace strainer screens. After cleaning and flushing hydronic piping system, but before balancing, remove disposable fine mesh strainers in pump suction diffusers.
C. Chemical Treatment: Provide hydronic systems with a water analysis prepared by the chemical treatment supplier to determine the type and level of chemicals required for prevention of scale and corrosion. Perform initial treatment after completion of system testing.

3.8 COMMISSIONING:

A. Fill system and perform initial chemical treatment.

B. Check expansion tanks to determine that they are not air bound and that the system is completely full of water.

C. Before operating the system perform these steps:

1. Open valves to full open position. Close coil bypass valves.
2. Remove and clean strainers.
3. Check pump for proper rotation and proper wiring.
4. Set automatic fill valves for required system pressure.
5. Check air vents at high points of systems and determine if all are installed and operating freely (automatic type) or to bleed air completely (manual type).
6. Set temperature controls so all coils are calling for full flow.
7. Check operation of automatic bypass valve.
8. Check and set operating temperature of boilers, chillers, and cooling towers to design requirements.
9. Lubricate motors and bearings.

END OF SECTION 23 21 13
PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. Extent of water treatment system work required by this section is indicated on drawings and schedules and by requirements of this section, and includes necessary equipment, chemicals, and service for the following systems:

1. Condenser Water Systems
2. Closed Hot Water Systems
3. Closed Chilled Water Systems
4. Steam Boiler Systems
5. Water Conditioners
6. Cleaning of Piping Systems
7. Sterilization of Domestic Water System

B. Provide chemicals and service program for a period of one year from start-up date of equipment, including the following:

1. Initial water analysis and recommendations.
2. Systems start-up assistance.
3. Training of operating personnel.
4. Periodic field service and consultation.
5. Customer report charts and log sheets.
6. Laboratory technical assistance.

1.2 QUALITY ASSURANCE:

A. The Water Treatment, Chemical and Service Company shall be recognized. Specialist, active in the field of industrial water treatment for at least ten years, whose major business is in the field of water treatment and shall have regional water analysis laboratories, development facilities and service department, plus full time service personnel within the locale of the job site.

B. All products shall be provided by a single subcontractor so ensure there is a single source of responsibility. Sub-contractor shall be on State approved list.

C. Firms must submit a list of satisfied customer service references and evidence of qualifications and experience for acceptance to execute the work on the project.

D. Codes and Standards:

1. ASME Compliance: Construct softener tanks in accordance with ASME Boiler and Pressure Vessel Code, Section VIII, provide stamp and certification.

2. UL Labels: Provide water conditioners ancillary electrical components, which have been listed and labeled by UL.

3. NEMA Standards: Provide electrical controls and enclosures conforming to applicable standards of NEMA for environment where water conditioners are indicated.
4. Chemical Standards: Provide only chemical products, which are acceptable under state and local public health and pollution control regulations.

1.3 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product including rated capacities of selected equipment clearly indicating water pressure drops, weights, installation and start-up instructions, and furnished specialties and accessories.

B. Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating dimensions, weight loadings, required clearances, and methods of assembly of components.

C. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to water treatment equipment. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

D. Record Drawings: At project closeout, submit record drawings of installed systems products in accordance with requirements of Divisions 1 and 23.

E. Maintenance Data: Submit maintenance data and parts list for each item of equipment, control, and accessory; including "trouble-shooting" maintenance guide. Include this data, product data, shop drawings, and wiring diagrams in maintenance manual, in accordance with requirements of Division 22 & 23.

1.4 DELIVERY, STORAGE AND HANDLING:

A. Handle water treatment materials and components carefully to prevent damage, breaking, denting and scoring to materials and equipment. Deliver packaged units in original crates. Do not install damaged water treatment materials and components; remove from site and replace with new.

B. Store water treatment materials and components in an environment satisfactory to prevent their damage by the elements.

1.5 MAINTENANCE:

A. Provide the services of a fully-qualified Field Engineer and laboratory and technical assistance from a fully-qualified laboratory staff for one year warranty period. Services and assistance shall include the following:

1. A training course for the University’s operating personnel, instructing them clearly and fully on the installation care, maintenance, testing and operation of the water treatment systems. Length of training shall be given as needed, per system size and complexity.

2. A periodic technical service visit to the job site to perform field inspections and to make water analysis on site, in order to evaluate the condition of the treated systems.

3. The Field Engineer shall report findings to the University’s operating personnel in writing on proper practices, chemical treating requirements and any corrective actions needed to protect the water systems from scale, corrosion and fouling.
PART 2 - PRODUCTS

2.1 SUPPLIERS/MANUFACTURERS:

A. Suppliers/Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Water Treatment System:
   a. Ashland Water Technologies

2. Chemical Feed Pumps
   a. LMI

3. Water Meters:
   a. LMI
   b. Badger
   c. Seametrics
   d. Neptune

4. Sonoxide Unit
   a. Ashland Water Technologies?

5. Conductivity Meters
   a. LMI-DC4500-111A with manifold 34752

6. Sand Filter
   a. Vortisand

2.2 PRE-CLEANING:

A. Closed Systems:

1. Hot and chilled water systems must be cleaned in the same manner prior to being ready for operation. The chemical cleaning must be alkaline material containing Dispersants, Detergent and Organic Corrosion inhibitors. Required system cleaner is Ashland Flushout 624L or UCB prior approved equivalent. Once system is properly dosed with chemical, circulate for 24 hours and if possible, heating system water up to 140-180deg F. Following circulation, drain down and flush. Fill, circulate 30 minutes and flush system until the water is clear and TDS of system water is ± 50 umhos that of city water. Once system has been properly flushed, add closed-system inhibitor (Nitrate based) to boost chilled water levels to 400-600 ppm as NO$_2$. Hot systems should be dosed with inhibitor to boost nitrate levels to 600-800 ppm. Required closed-system inhibitor is Ashland’s Drewgard 2808 unless prior approval is obtained by UCB.

B. Open Recirculating System (Cooling-Tower Water):

1. With system circulating, add a phosphate-based cleaner/passivation chemical. Liquid chemical should be a blend of inorganic phosphate, organic corrosion inhibitor, dispersant and an oil emulsifier. Ashland Flushout 2624 L, Ashland equivalent or prior approved equivalent by UCB is the required product. In order for optimum passivation and cleaning system, pH must be
maintained in the 6.5-7.5 range. Sulfuric acid may be gradually added to adjust pH if it increases above 7.5. Soda ash may be added if pH drops below 6.5. Sufficient Ashland Envirolplus 2503, Envirolplus 2499 should be added to raise total inorganic phosphate levels to 500 ppm minimum. Circulate for a minimum of 48 hours. Circulate and flush the system until TDS is ± 50 umhos that of city water. Verify all pump strainers are clean and functioning. Lay up the system dry until ready for use or begin recommended treatment program.

C. Steam Boiler:

1. Fill the boiler and add an alkaline cleaner containing detergents, emulsifiers and organic inhibitors. Ashland L.A.C. or prior approved equivalent by UCB is the required cleaner in sufficient amount to boost system pH to 11.0-12.0. Fire the boiler at normal operating levels and allow system pressure to build to 1/3 normal operating pressure. Fire for 4-6 hours then drain to ½ normal operating level in site glass. Add sufficient water to refill to normal operating level. Blowdown again to ½ normal operating level. Repeat this procedure at least 4 times allowing system pressure to drop during each flush. Allow the boiler to cool, then drain and flush. Begin normal treatment program or layup dry.

2.3 OPEN TYPE – COOLING TOWERS:

A. Inhibitor Feed and TDS Control for Cooling Towers:

1. Provide a proportional make-up chemical feed system where chemical feed is fed in proportion to the quantity of make-up water fed to the cooling tower. A certified contacting water meter shall be provided and installed in the make-up water line. The water meter will sense the quantity of make-up water in 10 gallon increments. Send and electrical signal to a cooling tower controller. The tower control device will accept and accumulate the electrical signals from the water meter. The correct contacting water meter may be specified by the chart below:

<table>
<thead>
<tr>
<th>TOWER</th>
<th>CONDENSER CIRC. RATE</th>
<th>RECOMMENDED WATER METER SIZE GALLON COUNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-200</td>
<td>0-6000</td>
<td>5/8” 10</td>
</tr>
<tr>
<td>300-400</td>
<td>900-1200</td>
<td>¾” 10</td>
</tr>
<tr>
<td>500-800</td>
<td>1500-2400</td>
<td>1” 10</td>
</tr>
<tr>
<td>900-1600</td>
<td>2700-4800</td>
<td>1-1/2” 10</td>
</tr>
<tr>
<td>1600-3000</td>
<td>4800-9000</td>
<td>2” 10</td>
</tr>
</tbody>
</table>

2. The controller must have the capability to actuate a variable timer when a predetermined number of signals is accepted from the water meter. The controller will be capable of activating the timer when 1 to 99 pulse-signals are sent to the controller. The timer circuit will activate a 110V circuit to energize a chemical pump for feeding scaled inhibitor.

3. Tower bleed will be controlled via a flow through TDS/conductivity sensor. The controller will read conductivity of the cooling water the 0-2000 microohms/cm range in a digital format on the front of the control device. The controller will be designed to energize a 110V circuit to open a solenoid bleed valve any time a preset conductivity is exceeded.

4. The controller will also include a 28-day programmable biocide time clock for feeding 2 (two) liquid biocides. The time clock shall be capable of energizing a 110V electrical outlet that can be used to energize a chemical feed pump for biocide, in 15-minute increments.

5. The controller will have a mounted flow assembly TDS sensor. Flow assembly will de-energize the controller when a loss of flow is sensed.
6. The required tower control unit is a LMI DC4500-111A, with LMI manifold (manifold contains flow switch and conductivity probe) or prior approved equivalent by UCB.

B. Inhibitor Feed and TDS Control for Cooling Towers 100 Tons and Smaller:

1. Provide a bleed and feed tower control system. Tower bleed will be controlled via a flow-through TDS/conductivity sensor. The control unit will read out in the 0-2000 micro mho/cm range in a digital format on the front of the control device. The controller will be designed to energize a 110V circuit to open a solenoid bleed valve any time preset conductivity is exceeded. While the solenoid bleed valve is open and additional 110V circuit will energize to provide power to a chemical feed pump.

2. Although the system will be designed to operate in the bleed and feed mode, the system should have the capability of accepting pulses from a contacting water meter. The control unit should be capable of energizing a 110V circuit for 0-300 second following receipt of a pulse from a contacting water meter. The controller will have a mounted flow assembly/TDS sensor. Flow assembly will de-energize the controller when a loss of flow is sensed. The required tower controller is a LMI DC4500-111A controller or prior approved equivalent by UCB. See attached parts list for required controller options for each tower configuration.

C. Inhibitor Feed Pumps

1. An electronically-actuated diaphragm pump will be provided. The pump must be a 110V, rated at 0.24-24GPD. Discharge pressure must be capable of overcoming the maximum pressure rating of the condenser water pump. Materials of construction are Polypropylene/Teflon/Ceramic. An LMI Model A151-392SI series pump or UCB prior approved equivalent is required. The inhibitor will be fed using the injector supplied with LMI pump.

D. Biocide Feeders for Towers:

1. An electronically-actuated diaphragm pump will be provided. The pump must be for 110V, rated at 0.24-24 GPD. Materials of construction are Polypropylene/Teflon/Ceramic. An LMI model A151-392SI or UCB prior approved equivalent is required. The pump shall be activated by the Tower control unit.

2. Injection quills of 304 stainless steel will only be used on injection points with 4” or greater pipe diameter, all others will use injection check valve supplied with LMI A151-392SI pumps or UCB prior approved equivalent.

3. Sonoxide unit and solid feeders see attached sheets e and f.

E. Sand Filter:

1. Provide an automatic sand filter for removing contaminates from the cooling tower water. The filter shall consist of a 304 stainless steel filter tank complete with pressure gauge and automatic air vent. Backwash shall be automatic, utilizing source water for backwash and will be initiated by pressure differential. The control valve shall be a multiport directional control valve with backwash timer and pressure differential switch.

2. Media shall remove 90 percent by volume of the suspended solids, 10 microns and larger.

3. The Control Box shall be NEMA 3R with thermal overload protection. A stepdown transformer will be supplied to convert power to 110 volt for controls, and motor starter. The complete unit shall be skid mounted on a steel channel skid.
2.4 OPEN TYPE SYSTEM – STEAM BOILERS:

A. Steam Boilers

1. TDS

   a. Provide a TDS control unit that periodically samples boiler water by opening the blowdown line for a short sampling period. If TDS is below the trip point, the blowdown valve closes after the timed sample. If TDS exceeds preset limits, the controller overrides the timer, allowing the blowdown valve to remain open until the system returns to the desired TDS.

2. Feed of Oxygen Scavenger:

   a. Sulfate based oxygen scavenger must be fed on a continuous basis. The chemical is fed using an injection quill that is positioned in the deaerator storage tank or the feed-water tank (if no deaerator exists). The injection quill should be constructed of 304 stainless steel. An electronically-actuated diaphragm pump rated at 0.24-24 gallons per day must be provided. Materials of construction are Polypropylene/Teflon/Ceramic. An LMI model A151-392SI or UCB prior approved equivalent.

3. Inhibitor Feed:

   a. Scale inhibitors are fed into the suction side of the feed water pumps using a 304 stainless steel injection quill. An electronically-actuated diaphragm pump rated at 0.24-24 GPD must be provided. Materials of construction are Polypropylene/Teflon/Ceramic. A LMI model A151-392SI pump or UCB prior approved equivalent is required. The inhibitor pump should be wired such that it will energize when the feed pump runs or when make-up water is supplied to the boiler system. Operators must have the option of either control mode by providing a dual-receptacle plug. One plug will energize based on the feed pump the other will energize when make-up water is called for.

4. Water Softener:

   a. A water softener must be provided for all steam boilers. It shall be capable of producing a consistent supply of make-up water containing <0.5 ppm total hardness. The softener must be equipped with a salt tank and provisions for automatic regeneration bases on total gallons supplied by the unit.

   b. If the boiler is an intermittent-operating unit that shuts down for at least 4 hours per day, a single softener vessel system must be provided. If the boiler runs on a continuous basis, a dual-vessel system must be provided. The dual-vessel system will regenerate the exhausted vessel as soon as the new vessel is put into service. See attached schematic WT-7A and parts list WT-7B.

2.5 CLOSED SYSTEMS:

A. All hot-water or chilled-water closed-loop systems under 1,000 gallons shall have a 2 gallon bypass (pot) filter feeder installed.

B. All hot-water or chilled-water closed-loop systems over 1,000 gallons shall have a 5 gallon by-pass filter feeder installed.

C. A Neptune by-pass filter feeder or prior approved equivalent by UCB will be provided. The vessel will be constructed of mild steel and be capable of operating up to 200 psig. A filter bag kit should be
provided to fit inside the feeder. The bag filter will remove scale, rust, chips, etc. from the system. This bag filter shall be marked “bag inside.”

D. The contractor installing the bypass filter feeder will be required to provide piping and valves for installation of this feeder. See attached schematic WT-D and parts list WT-D.

2.6 CORROSION COUPON RACKS:

A. Corrosion coupon racks shall be supplied on all process-cooling, heating water, chilled-water and water systems served by open cooling towers, such as condensers and indirect evap-cooling coils. All racks shall be constructed of 1” Sch 80 PVC pipe with the exception of hot water systems which should be Sch 80 mild steel pipe. Coupon racks should be capable of accepting two corrosion test specimens. An orifice-valve must be supplied in each rack which provides a 3.0-4.0 ft/sec flow throughout the rack. A flowmeter shall be installed near the coupon rack, after orifice-valve. Flowmeter shall be within 1 foot of union.

B. When installing a rack in the condenser water system, the warmest water in the system should be the supply water to the coupon rack. Usually, the water exiting the condenser would be considered supply to the coupon rack.

2.7 DOMESTIC WATER STERILIZATION:

A. 10% bleach will be used to perform the sterilization. Bleach will be fed by injecting it into the main water supply header feeding the facility. An LMI Model A151-392SI chemical feed pump is to be used for injection of bleach. Below is the sterilization procedure.

1. Run all domestic water supply faucets at ½-1/4 gall per minute.
2. Begin pumping bleach and adjust bleach injection rate such that a 1.0-2.0 ppm free C12 residual is attained at all faucets.
3. Maintain above flow rates and free chlorine residuals for a 4-6 hour period.
4. Cease bleach injection. Monitor free C12 residuals at faucets and observe when free C12 residual drops below 0.2 ppm. Run all faucets for an additional two hours at a ½-1/4 gallon per minute rate.

B. System is now considered a sterile and ready for operation.

2.8 WYE STRainers:

A. Threaded wye strainers shall have screens of 20 mesh maximum, watts preferred or prior approved equivalent.

2.9 SPILL CONTAINMENT:

A. Spill containment made of polypropylene (or equivalent) or concrete shall be provided. Total volume of containment shall exceed total volume of chemical containers by 50%. Concrete containments must have ramp inside and outside. Containments using 30 drums or greater mush have ramp to drum platform level.

PART 3 - EXECUTION

3.1 CLEANING OF PIPE LINES AND BOILERS:

A. The water treatment contractor shall be responsible for furnishing the cleaning material and supervising the chemical cleaning of the hydronic piping and boilers.
3.2 INSTALLATION/APPLICATION:

A. Install per the following:

1. Emergency eye wash/shower (potable water) shall be located at or in close proximity (within 10’) to chemical treatment station with no obstruction or tripping hazards in between chemical containers, filter-feeder, chemical pumps and conductivity controller are considered chemical treatment station.

2. Chemical treatment station shall be located at or in close proximity to sanitary sewer floor drain or be constrained in a basin piped to sanitary drain.

3. All chemical pumps shall be mounted no higher than 5 foot above floor elevation, with 4 foot being the optimal height.

4. All chemical pumps shall be located within 5 feet of conductivity controller.

5. Wye strainers must be installed before (upstream) of all controller sensors, bleed solenoids before controller sensor can be used for both controller and coupon rack. On systems 1,500 gallons or less, wye strainer located before controller sensor can be used for both controller and coupon rack. Systems over 1,500 gallons shall have wye strainers upstream of coupon rack, one upstream of controller and one upstream of bleed solenoid.

6. Conductivity controller must be mounted on fixed walls or stands free of vibration. Controller shall not be mounted on cooling towers, duct work or air handlers. Controller must be insulated from extreme cold and heat if installed on building exterior wall. All controllers shall be mounted between 5’ x 6” above floor (eye level). 36” clearance in front of controller is required.

7. All chemical pumps must be secured to shelf or support to prevent any movement due to pump action or normal contact.

8. All chemical pumps and conductivity controllers must be 110 volt, 60 Hz.

3.3 SONOXIDE WATER TREATMENT SYSTEM:

A. Water treatment for cooling towers using non-chemical microbiological control systems.

1. Provide complete chemical treatment program including corrosion inhibitor and non-chemical mechanical system for microbiological control.

2. The biocide system will be Ashland Water Technologies’ SONOXIDE ultrasonic treatment. No other non-mechanical devices will be accepted.
   a. The biocide equipment for the tower water treatment shall be a complete packaged, pre-piped, pre-wired, automatic system.
   b. Installation will require piping the inlet and outlet of the SONOXIDE system to the cooling tower system. Installation also requires wiring the power supply to the SONOXIDE system. Installation will be provided by others.
   c. The biocide unit shall have a fail safe back up control and warning alarm in the event of operational malfunction such as loss of water flow. This output will be wired to the Andover Building management system.
d. The biocide equipment will be run independently of the bulk water inhibitor and not be connected to the conductivity control equipment.

e. All maintenance of the unit shall be the responsibility of the vendor. Any and all replacement parts to keep the unit operational will remain the responsibility of the vendor for the life of the contract.

f. 24 hour emergency response to be provided to keep unit operational.

g. The contractor is to abide by the following terms and conditions.

h. The contractor is to fill out and submit with the shop drawing submittals the following signed documents and agreements regarding terms of use/contractor acknowledgement and terms of use.

B. Terms of Use:

1. The SONOXIDE equipment provided is to be kept in good condition, normal wear and tear excepted. Additionally, an Ashland representative or an outside designee of Ashland may periodically perform an inspection or otherwise need access to the equipment. You will do everything in your power to prevent damage and reimburse Ashland for any damages that may occur while the equipment is under your control. Pricing to include all necessary items for the initial 12 month warranty period.

2. The SONOXIDE ultrasonic water treatment system is patented and proprietary. Therefore, embodied within the equipment is certain information of a confidential and proprietary nature, and you agree not to reverse engineer, disassemble or create an equivalent of the equipment or allow others to do so. You will also keep information not in the public domain relating to the equipment and the procedures associated with the operation thereof confidential. You further agree that you will use said information only in connection with your receipt of Ashland’s performance and for no other reason.

3. The obligations contained in this section shall be binding to Ashland, the University and their legal successors.

END OF SECTION 23 25 00
SECTION 23 25 10

GLYCOL SYSTEMS

PART 1 GENERAL

1.1 DESCRIPTION OF WORK:

A. Extent of glycol system required by this section is indicated on drawings and/or specified in other Division 15 sections.

B. Types of glycol system specialties specified in this section include the following:
   1. Fill tank
   2. Pressure sensor
   3. Pressure relief valve
   4. Check valve
   5. Ethylene glycol
   6. Feed Pump
   7. Transfer Pump

C. Glycol systems specialties furnished as part of factory-fabricated equipment shall meet or exceed requirements of this section.

D. Refer to other Division 15 sections for mechanical insulation valves, meters and gauges and basic piping materials and methods.

1.2 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of glycol systems of types and sizes required, whose products have been in satisfactory use in similar service for not less than 10 years.

B. Glycol System Types: Provide glycol system specialties of same type by same manufacturer.

C. Codes and Standards: Provide glycol system components and materials to meet all local and national codes and standards.

1.3 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data, including installation instructions and dimensioned drawings for each type of manufactured equipment and material. Include pressure drop information. Submit schedule showing manufacturer's model or figure number, size, location and features for all equipment and material.

B. Maintenance Data: Submit maintenance data and spare parts lists for each type of manufactured equipment. Include this data, product data, and shop drawings in maintenance manual; in accordance with requirements of Division 15.

C. Submit glycol solution strength test results.
PART 2 PRODUCTS

2.1 MANUFACTURERS:

A. Manufacturer: Subject to compliance with requirements, provide products by one of the following:

1. Glycol System Tank:
   a. Wetcorp
   b. Sage Industries
   c. Nalco
   d. Mogul
   e. Chem Aqua
   f. H.O.H.

2. Inhibited Ethylene Glycol Solution:
   a. Dow Chemical Dowfrost
   b. Interstate Chemical Intercool NFP.

2.2 REFER TO DIVISION 15, SECTION 15055 FOR TYPE OF PIPE AND FITTINGS TO BE USED.

2.3 GLYCOL SYSTEM:

A. Tank: Provide Glycol Feed System consisting of a 35 gallon polyethylene tank with a removable polyethylene cover. A ½ inch suction and under drain with hose bib for draining the tank and a pump shut off valve shall be provided. The tank shall be supported by 4 legs with foot pads as an integral part of the tank.

B. Controls: The control cabinet shall be a NEMA 1 enclosure with a large LEXAN viewing window mounted in the cabinet door. The following components shall be mounted on the inside panel: Low level liquid alarm light, low level alarm silencer switch, pump test switch and indicating light, and a 0-60 psi system pressure gauge. The low level switch shall be mounted 3 inches above the bottom of the tank. A low level audible alarm shall be mounted in the side of the panel. In addition, two extra, normally open contacts shall be provided for remote low level warning light or alarm. A 3-35 psi adjustable pressure switch shall control the system pressure.

C. Pump: The pump shall be an Oberdorfer, all bronze, rotary gear pump with a 1/3 hp-1725 rpm motor mounted integrally with the pump. The pump shall be designed to produce 1.8 gpm at 40 psi. Electrical characteristics: 120V./60Hz/1 phase/1/3 HP.

D. Piping: Type L copper pump discharge, including a 3/4 inch check valve, 3/4 inch threaded female "T" for connecting the Glycol Feeder to the system piping, and a Watts pressure relief valve set at 50 psi, which will dump any system over pressure back to the glycol feed tank.

E. Transfer Pump: Hand operated rotary type, 8 feet-0 inches long 1 inch hose with 3/4 inch non-sparkling nozzle, 1 inch telescoping suction pipe, adaptor with 2 inch thread.

2.4 GLYCOL SOLUTION:

A. Provide glycol solutions as follows:

1. Heat Recovery – 40%
2. Glycol Heating System – 30%

B. Provide on extra 45 gallon drum of ethylene glycol.

PART 3 EXECUTION

3.1 INSTALLATION:

A. Refer to drawing and provide necessary piping to complete installation.

B. Thoroughly clean and flush system before adding glycol solution.

C. Feed pre-mixed glycol solution to system. Water used for dilution shall have a total hardness of less than 50 ppm, and a total chloride and sulfate of less than 25 ppm. Contractor shall assume that building potable water is not suitable, unless tested to prove otherwise.

D. Perform tests determining strength of glycol solution before system is turned over to the Owner. Provide test prior to end of the first year of operation and replenish as required.

E. Set up glycol feeder control for proper operation. Set pressure switch to feed glycol to system at 12 psi.

F. At time of substantial completion, glycol feeder shall be filled with a full tank of the proper solution.

END OF SECTION 23 25 10
 SECTION 23 31 13
METAL DUCTWORK

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. Extent of metal ductwork is indicated on drawings and in schedules, and by requirements of this section.

<table>
<thead>
<tr>
<th>DUCT SERVICE</th>
<th>TYPE/CONSTRUCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply air between fan and terminal boxes (medium).</td>
<td>Galvanized steel, spiral, round or oval /rectangular.</td>
</tr>
<tr>
<td>Rectangular supply air from discharge of terminal box/fan to air devices (low pressure).</td>
<td>Galvanized sheet metal /spiral round and oval or rectangular (internally lined.)</td>
</tr>
<tr>
<td>Return air ductwork.</td>
<td>Galvanized steel (internally lined) factory or shop fabricated.</td>
</tr>
<tr>
<td>General building exhaust.</td>
<td>Galvanized sheet metal (internally lined) factory or shop fabricated.</td>
</tr>
<tr>
<td>Transfer ducts.</td>
<td>Internally lined galvanized sheet metal as described above for low pressure supply; factory or shop fabricated.</td>
</tr>
<tr>
<td>Sound elbows for R.A. grilles</td>
<td>Galvanized sheet metal (internally lined).</td>
</tr>
<tr>
<td>Laboratory general exhaust, fume hood exhaust risers, mains and branch ducts including fume hoods.</td>
<td>PVC coated ductwork; factory or shop fabricated. (lined where noted on drawings for general exhaust)</td>
</tr>
<tr>
<td>Outdoor air intake ductwork.</td>
<td>Galvanized sheet metal, rectangular, factory or shop fabricated.</td>
</tr>
<tr>
<td>Dishwasher exhaust. tunnelwash exhaust.</td>
<td>Aluminum with silicone sealant.</td>
</tr>
<tr>
<td>Cagewash, Autoclave</td>
<td>Type 304 stainless steel, welded to point of dilution with exhaust system.</td>
</tr>
<tr>
<td>Kitchen grease exhaust.</td>
<td>Exposed To View: Type 304 stainless steel, min. 18 GA all welded construction, with welds ground smooth for a #4 finish.</td>
</tr>
<tr>
<td>Exterior uninsulated ductwork.</td>
<td>Epoxy coated steel painted light gray</td>
</tr>
<tr>
<td>Shower, locker room exhaust.</td>
<td>Aluminum with silicone sealant.</td>
</tr>
</tbody>
</table>

B. Exterior insulation of metal ductwork is specified in other Division 23 sections, and is included as work of this section.

C. Refer to other Division-23 sections for ductwork accessories.
D. Refer to other Division-23 sections for fans and air handling units.

E. Refer to other Division-23 sections for testing, adjusting, and balancing of metal ductwork systems.

1.2 DEFINITIONS:

A. Low Pressure Duct: Duct required by the drawings, specifications, or referenced standards to be constructed to 2" or less, positive or negative pressure class.

B. Medium or High Pressure Duct: Duct required by the drawings, specifications, or referenced standards to be constructed to greater than 2" positive or negative pressure class.

1.3 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of metal ductwork products of types, materials, and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Installer's Qualifications: Firm with at least 3 years of successful installation experience on projects with metal ductwork systems similar to that required for project.

C. References to SMACNA, ASHRAE and NFPA are minimum requirements, the Contractor shall fabricate, construct, install, seal and leak test all ductwork as described in this specification and as shown on the drawings, in addition to these minimum standard references.

D. Codes and Standards:

1. SMACNA Standards: Comply with SMACNA's "HVAC Duct Construction Standards, Metal and Flexible" for fabrication and installation of metal ductwork. Comply with SMACNA "HVAC Air Duct Leakage Test Manual" for testing of duct systems.


E. SMACNA Industrial Construction Standards.


1.4 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data and installation instructions for ductwork materials and products. Provide product data for manufactured joining systems. Include sound attenuation by octave band for sound rated flexible duct.

B. Shop Drawings: Submit 1/4" scaled fabrication and layout drawings of metal ductwork and fittings including, but not limited to, duct sizes, locations, elevations, and slopes of horizontal runs, wall and floor penetrations, and connections. Show interface and spatial relationship between ductwork and proximate equipment. Show modifications of indicated requirements, made to conform to local shop practice, and how those modifications ensure that free area, materials, and rigidity are not reduced.

C. Record Drawings: At project closeout, submit record drawings of installed systems, in accordance with requirements of Divisions 1 and 15.
D. Maintenance Data: Submit maintenance data and parts lists for metal ductwork materials and products. Include this data, product data, shop drawings, and record drawings in maintenance manual; in accordance with requirements of Divisions 1 and 15.

1.5 DELIVERY, STORAGE, AND HANDLING:

A. Protection: Protect shop-fabricated and factory-fabricated ductwork, accessories and purchased products from damage during shipping, storage and handling. Prevent end damage and prevent dirt and moisture from entering ducts and fittings. By providing end caps on all open sections, bagging small fittings, surface wrapping and shrink wrapping.

B. Storage: Store ductwork inside elevated from floor on pallets. At no time shall the inside surfaces be exposed, or stored with open ends and protect from weather.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Duct Liner:
   a. CertainTeed Corp.
   b. Manville Products Corp. (Schuller)
   c. Owens-Corning Fiberglas Corp.
   d. Pittsburgh Corning Corp.

2. Flexible Ducts:
   a. Flexmaster
   b. Thermaflex

3. Duct Take Off Fittings
   a. Hercules Industries
   b. Flexmaster
   c. Thermaflex
   d. Ominair

4. Round and flat oval Ductwork (low, medium, and high pressure):
   a. Semco Mfg., Inc.
   b. United Sheet Metal Div., United McGill Corp.
   c. Sheet Metal Products Co.
   d. Spiral Pipe of Texas, Inc.
   e. Hercules Industries

5. PVC Coated Ducts:
   a. Foremost
   b. Norlock
   c. Semco
   d. Hercules

6. Triple Lock Aluminum Round Ductwork (Uninsulated):
a. Manufacturers:

1) Flexmaster Triple Lock Type NITL Flexible Aluminum Air Duct
2) Hercules
3) Omni Air
4) Thermaire

7. Insulated Triple Lock Aluminum Round Ductwork:

a. Manufacturers:

1) Flexmaster Triple Lock Type TL-M Aluminum Duct Insulated
2) Hercules
3) Omni Air
4) Thermaire

2.2 DUCTWORK MATERIALS:

A. Exposed Ductwork Materials: Where ductwork is exposed to view in occupied spaces, provide materials which are free from visual imperfections including pitting, seam marks, roller marks, stains, dents, discolorations, and other imperfections, including those which would impair painting.

B. Sheet Metal: Except as otherwise indicated, fabricate ductwork from galvanized sheet steel complying with ASTM A 527, lockforming quality; with G 90 zinc coating in accordance with ASTM A 525; and mill phosphatized for exposed locations. Provide flat seam construction where standing seams are a hazard to the Owner's operation personnel.

C. Stainless Steel Sheet: Where indicated, provide stainless steel complying with ASTM A 167; Type 304 or 316; with No. 4 finish where exposed to view in occupied spaces, No. 1 finish elsewhere. Protect finished surfaces with mill-applied adhesive protective paper, maintained through fabrication and installation.


E. Uncoated carbon steel shall comply with ASTM A569, hot rolled steel sheet.

2.3 PVC COATED DUCTWORK:

A. Steel:

1. Hot dipped galvanized steel, lock forming quality.

2. Pretreatment: Ductwork shall be cleaned and treated to accept a primer.

3. Primer: Reverse rollcoat application of primer.

4. Bake: Primer shall be oven cured.

5. Quench: Water drenched and air dried.

6. PVC: Film polyvinyl chloride (PVC) dispersion.

7. Finish: Bake.

8. Film Properties - PVC:
a. Flexibility: 180°OT bend with no peeling.
c. Surface: Smooth, non-embossed or plenished. Free of blisters, sags, stringers, and voids.
d. Weight/Density: .035 lbs./sq. ft. @ 5 mils.
e. Hardness: 90 units A scale, Shore - Durometer, minimum.
f. Gloss: Medium.

B. For laboratory general exhaust and fume hood exhaust inside of duct shall have 4 mil thickness with 4 mil exterior.

2.4 MISCELLANEOUS DUCTWORK MATERIALS:

A. General: Provide miscellaneous materials and products of types and sizes indicated and, where not otherwise indicated, provide type and size required to comply with ductwork system requirements including proper connection of ductwork and equipment.

B. Fittings: Provide radius type fittings fabricated of multiple sections with maximum 15 deg. change of direction per section. Unless specifically detailed otherwise, use 45 deg. laterals and 45 deg. elbows for branch takeoff connections. Where 90 deg. branches are indicated, provide conical type tees.

C. Duct Liner: Fibrous glass, complying with Thermal Insulation Manufacturers Association (TIMA) AHC-101; of thickness indicated.
   1. Unless otherwise noted, provide 1" thick, 1-1/2 lb density, fiberglass duct liner meeting ASTM C1071 Type I, NFPA 90A and 90B and TIMA (AHC-101) with minimum NRC (noise reduction coefficient) of 0.70 as tested per STM C 423 using an "A" mounting with minimum "K" factor of 0.25. Lining shall be U.L. approved, made from flame attenuated glass fiber bonded with a thermosetting resin with acrylic smooth surface treatment and factory applied edge coating. Materials shall conform to revised NFPA No. 90A Standards, with a maximum flame spread of 25 and maximum smoke development of 50.
   2. Provide rigid plenum liner board where indicated. Rigid liner shall be 1" thick, 3 pounds per cubic foot, glass fiber bonded with thermosetting resin, with an acrylic coating, conforming to NFPA 90 and ASTM C1071.
      a. Schuller/Manville Permacote Linacoustic R-300.

D. Duct Liner Adhesive: Comply with ASTM C 916 "Specifications for Adhesives for Duct Thermal Insulation".

E. Duct Liner Fasteners: Comply with SMACNA HVAC Duct Construction Standards, Article S2.11.

F. Duct Sealant: Non-hardening, non-migrating mastic or liquid elastic sealant, type applicable for fabrication/ installation detail, as compounded and recommended by manufacturer specifically for sealing joints and seams in ductwork. All PVC coated exhaust ductwork shall be sealed with an approved chemical resistant sealant as manufactured by Foremost Co. PCD No. 8 duct sealer and wrap with hardcast tape. For outdoor ductwork, sealant shall also be U.V. resistant and weather resistant.

G. Ductwork Support Materials: Except as otherwise indicated, provide hot-dipped galvanized steel fasteners, anchors, rods, straps, trim and angles for support of ductwork.
   1. For exposed stainless steel ductwork, provide matching stainless steel support materials.
   2. For aluminum ductwork, provide aluminum support materials except where materials are electrolytically separated from ductwork.
H. Flexible Ducts: Flexible air ducts shall be listed under UL-181 standards as Class I Air Duct Material and shall comply with NFPA Standards 90A and 90B. Minimum operating pressure rating shall be 6" W.C. through a temperature range of -20° to 150°F; minimum working velocity rating shall be 4000 f.p.m. Contractor shall assume responsibility for supplying material approved by the authority having jurisdiction.

1. All flexible duct shall be rated for sound attenuation. Inner core shall be black CPE supported by a galvanized steel helix, with 1" C=.23 or less insulation and metalized reinforced outer jacket. Sound attenuation shall be as scheduled below:

<table>
<thead>
<tr>
<th>Octave Band</th>
<th>125</th>
<th>250</th>
<th>500</th>
<th>1000</th>
<th>2000</th>
<th>4000</th>
</tr>
</thead>
<tbody>
<tr>
<td>IL (dB) 8&quot; dia.</td>
<td>13</td>
<td>31</td>
<td>36</td>
<td>35</td>
<td>38</td>
<td>21</td>
</tr>
</tbody>
</table>

a. Flexmaster Type 8M

I. Duct Take Off Fittings to Individual Air Inlets & Outlets: Provide conical spin-in fittings with 1” standoffs and heavy duty dampers at flexible or round sheet metal duct takeoffs. Where specifically shown on drawings, where the duct dimension does not allow for a conical spin-in, or at Contractor's option, provide 45° inlet rectangular to round duct take off fittings, with factory applied gasket. Fittings shall include butterfly type manual volume damper with regulator, and dual locking device. Dual locking device shall consist of two shaft mounted wing nuts, one on each side of the damper. Wing nuts shall tighten on shafts to lock butterfly in place. Shafts shall be solid metal, rolled metal shafts are not acceptable.

Hercules Model 9000 (conical)

J. See detail on drawings for installation requirement.

K. All fasteners and hardware for stainless steel ductwork shall be made of stainless steel.

2.5 FABRICATION:

A. Fabricate ductwork in 4, 8, 10 or 12-ft lengths, unless otherwise indicated or required to complete runs. Preassemble work in shop to greatest extent possible, so as to minimize field assembly of systems. Disassemble systems only to extent necessary for shipping and handling. Match-mark sections for reassembly and coordinated installation.

B. Fabricate ductwork of gauges and reinforcement complying with SMACNA "HVAC Duct Construction Standards". Minimum 26 GA where ducts are within corridors.

C. Where the standard allows the choice of external reinforcing or internal tie rods, only the external reinforcing options shall be used.

D. If manufacturer flange joining systems are used as part of the reinforcing, the EI rating and rigidity class shall be equivalent to the reinforcing requirements of the standard. Submit manufacturer's product data.
E. Aluminum duct shall be fabricated using the aluminum thickness equivalence table in the standard. Simply increasing the thickness by two gauges is not acceptable.

F. Fabricate duct fittings to match adjoining ducts, and to comply with duct requirements as applicable to fittings. Except as otherwise indicated, fabricate elbows with center-line radius equal to 1.5 times the associated duct width; and fabricate to include single wall turning vanes in elbows where shorter radius is necessary. Rails shall be 2” wide for elbow up to 12”, and 4” wide for elbows over 12” wide. Limit angular tapers to 30 deg. for contracting tapers and 20 deg. for expanding tapers. Divided flow fittings shall be 45° inlet branches, stationary splitters and elbows, or as shown on drawings.

G. Fabricate ductwork with accessories installed during fabrication to the greatest extent possible. Refer to Division-23 section "Ductwork Accessories" for accessory requirements. All exhaust ductwork accessories (including dampers, turning vanes, access doors, etc.) shall be Heresite or PVC coated. All stainless steel ductwork shall have stainless steel accessories (including dampers, turning vanes, access doors, etc.) construction.

H. Fabricate ductwork with duct liner in each section of duct where indicated. Laminate liner to internal surfaces of duct in accordance with instructions by manufacturers of lining and adhesive, and fasten with mechanical fasteners. Provide sheet metal nosing on all leading edges preceded by unlined duct, at duct openings, and at fan or terminal unit connections.

2.6 LOW PRESSURE ROUND DUCTWORK:

A. Material: Galvanized sheet steel complying with ASTM A 527, lockforming quality, with ASTM A 525, G90 zinc coating, mill phosphatized. Spiral lockseam construction. Individual runouts to diffusers may be longitudinal seam.

B. Gauge: 28-gauge minimum for round and oval ducts and fittings, 4” through 24” diameter. Minimum 26 gauge where ducts are within a corridor.

C. Elbows: One piece construction for 90 deg. and 45 deg. elbows 14” and smaller. Provide multiple gore construction for larger diameters with standing seam circumferential joint. Radius to centerline shall be 1.5 times duct diameter. Spot welded and bonded construction.

D. Divided Flow Fittings: 90 deg. tees, constructed with branch spot welded and bonded to duct fitting body.

2.7 MEDIUM PRESSURE ROUND AND FLAT OVAL DUCTWORK:

A. General: Provide factory-fabricated duct and fittings.

B. Duct gauges given below are minimum values; in no case shall the duct gauge be less than recommended by SMACNA for the operation pressures of the systems shown on the drawings, (both positive and negative pressures), including proper re-enforcement.

C. Elbows: One piece construction for 90 deg. and 45 deg. elbows 14” and smaller. Provide multiple gore construction for larger diameters with standing seam circumferential joint. Radius to centerline shall be 1.5 times duct diameter. Fully welded construction.

D. Divided Flow Fittings: Full body fittings with solid welded construction. Provide conical laterals, conical tees, 45° inlet tees, wye fittings, or as shown on drawings. Straight tap tees shall not be used.

E. Round Ductwork: Construct of galvanized sheet steel complying with ASTM A 527 by the following methods and in minimum gauges listed.
1. Provide locked seams for spiral duct; fusion-welded butt seam for longitudinal seam duct. Provide internal stiffener rings and external reinforcement as required to meet operating static pressures scheduled on drawings.

2. Fittings and Couplings: Construct of minimum gauges listed. Provide continuous welds along seams.

### Diameter Minimum Gauge Method of Manufacture

<table>
<thead>
<tr>
<th>Diameter</th>
<th>Minimum Gauge</th>
<th>Method of Manufacture</th>
</tr>
</thead>
<tbody>
<tr>
<td>3&quot; to 14&quot;</td>
<td>26</td>
<td>Spiral Lockseam</td>
</tr>
<tr>
<td>15&quot; to 26&quot;</td>
<td>24</td>
<td>Spiral Lockseam</td>
</tr>
<tr>
<td>27&quot; to 36&quot;</td>
<td>22</td>
<td>Spiral Lockseam</td>
</tr>
<tr>
<td>37&quot; to 50&quot;</td>
<td>20</td>
<td>Spiral Lockseam</td>
</tr>
<tr>
<td>51&quot; to 60&quot;</td>
<td>18</td>
<td>Spiral Lockseam</td>
</tr>
<tr>
<td>Over 60&quot;</td>
<td>16</td>
<td>Longitudinal Seam</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>Spiral Lockseam</td>
</tr>
</tbody>
</table>

1. Provide locked seams for spiral duct; fusion-welded butt seam for longitudinal seam duct.

F. Flat-Oval Ductwork: Construct of galvanized sheet steel complying with ASTM A 527, of spiral lockseam construction, in minimum gauges listed.

### Diameter Minimum Gauge

<table>
<thead>
<tr>
<th>Diameter</th>
<th>Minimum Gauge</th>
</tr>
</thead>
<tbody>
<tr>
<td>3&quot; to 14&quot;</td>
<td>24</td>
</tr>
<tr>
<td>15&quot; to 26&quot;</td>
<td>22</td>
</tr>
<tr>
<td>28&quot; to 50&quot;</td>
<td>20</td>
</tr>
<tr>
<td>52&quot; to 60&quot;</td>
<td>18</td>
</tr>
<tr>
<td>Over 62&quot;</td>
<td>16</td>
</tr>
</tbody>
</table>

F. Flat-Oval Ductwork: Construct of galvanized sheet steel complying with ASTM A 527, of spiral lockseam construction, in minimum gauges listed.

### Maximum Width Minimum Gauge

<table>
<thead>
<tr>
<th>Maximum Width</th>
<th>Minimum Gauge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 25&quot;</td>
<td>24</td>
</tr>
<tr>
<td>25&quot; to 48&quot;</td>
<td>22</td>
</tr>
<tr>
<td>49&quot; to 70&quot;</td>
<td>20</td>
</tr>
<tr>
<td>Over 70&quot;</td>
<td>18 (or 16 GA. Longitudinal welded seam)</td>
</tr>
</tbody>
</table>

1. Fittings and Couplings: Construct of minimum gauges listed. Provide continuous weld along seams.
G. Internally Insulated Duct and Fittings: Construct with outer pressure shell, 1" thick insulation layer, and perforated inner liner. Construct shell and liner of galvanized sheet steel complying with ASTM A 527, of spiral lockseam construction, use longitudinal seam for over 59", in minimum gauges listed.

<table>
<thead>
<tr>
<th>Nominal Duct Diameter</th>
<th>Outer Shell</th>
<th>Inner Liner</th>
</tr>
</thead>
<tbody>
<tr>
<td>3&quot; to 12&quot;</td>
<td>26 ga.</td>
<td>26 ga.</td>
</tr>
<tr>
<td>13&quot; to 24&quot;</td>
<td>24 ga.</td>
<td>26 ga.</td>
</tr>
<tr>
<td>25&quot; to 34&quot;</td>
<td>22 ga.</td>
<td>26 ga.</td>
</tr>
<tr>
<td>35&quot; to 48&quot;</td>
<td>20 ga.</td>
<td>26 ga.</td>
</tr>
<tr>
<td>49&quot; to 62&quot;</td>
<td>18 ga.</td>
<td>26 ga.</td>
</tr>
<tr>
<td>Over 62&quot;</td>
<td>18 ga.</td>
<td>22 ga.</td>
</tr>
</tbody>
</table>

1. Fittings and Couplings: Construct of minimum gauges listed. Provide continuous weld along seams of outer shell.

<table>
<thead>
<tr>
<th>Nominal Duct Diameter</th>
<th>Outer Shell</th>
<th>Inner Liner</th>
</tr>
</thead>
<tbody>
<tr>
<td>3&quot; to 34&quot;</td>
<td>20 ga.</td>
<td>24 ga.</td>
</tr>
<tr>
<td>36&quot; to 48&quot;</td>
<td>20 ga.</td>
<td>22 ga.</td>
</tr>
<tr>
<td>50&quot; to 58&quot;</td>
<td>18 ga.</td>
<td>22 ga.</td>
</tr>
<tr>
<td>Over 58&quot;</td>
<td>16 ga.</td>
<td>22 ga.</td>
</tr>
</tbody>
</table>

2. Inner Liner: Perforate with 3/32" holes for 22% open area. Provide metal spacers welded in position to maintain spacing and concentricity.

PART 3 - EXECUTION

3.1 INSPECTION:

A. General: Examine areas and conditions under which metal ductwork is to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF METAL DUCTWORK:

A. Duct Sealing:

1. Seal all low pressure ducts to SMACNA Seal Class "B".
2. Seal all medium and high pressure ducts to SMACNA Seal Class "A".
B. General: Assemble and install ductwork in accordance with recognized industry practices which will achieve air-tight and noiseless (no objectionable noise) systems, capable of performing each indicated service. Install each run with minimum number of joints. Align ductwork accurately at connections, within 1/8" misalignment tolerance and with internal surfaces smooth. Support ducts rigidly with suitable ties, braces, hangers and anchors of type which will hold ducts true-to-shape and to prevent buckling, popping or compressing. Support vertical ducts at every floor.

C. Construct ductwork to schedule of operating pressures as shown on drawings.

D. Inserts: Install concrete inserts for support of ductwork in coordination with formwork, as required to avoid delays in work.

E. Field Fabrication: Complete fabrication of work at project as necessary to match shop-fabricated work and accommodate installation requirements.

F. Routing: Locate ductwork runs, except as otherwise indicated, vertically and horizontally and avoid diagonal runs wherever possible. Locate runs as indicated by diagrams, details and notations or, if not otherwise indicated, run ductwork in shortest route which does not obstruct useable space or block access for servicing building and its equipment. Hold ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building. Limit clearance to 1/2" where furring is shown for enclosure or concealment of ducts, but allow for insulation thickness, if any. Where possible, locate insulated ductwork for 1" clearance outside of insulation. Wherever possible in finished and occupied spaces, conceal ductwork from view, by locating in mechanical shafts, hollow wall construction or above suspended ceilings. Do not encase horizontal runs in solid partitions, except as specifically shown. Coordinate layout with suspended ceiling and lighting layouts and similar finished work.

G. Electrical Equipment Spaces: Do not route ductwork through transformer vaults and their electrical equipment spaces and enclosures.

H. Slope shower, locker room, and high moisture ductwork down to air device.

I. Penetrations: Where ducts pass through fire rated walls and do not contain fire or smoke dampers, protect with fire stop material installed in accordance with its listing. Where ducts pass through interior partitions or exterior walls, and are exposed to view, conceal space between construction opening and duct or duct insulation with sheet metal flanges of same gauge as duct. Overlap opening on all four sides by at least 1-1/2". Fasten to duct only. Where ducts penetrate non-fire rated, mechanical, electrical or acoustically sensitive walls, provide 1/2" to 3/4" annular space between duct and wall, pack annular space with mineral wood insulation, and caulk both sides with non-hardening acoustical sealant.

J. Coordination: Coordinate duct installations with installation of accessories, dampers, coil frames, equipment, controls and other associated work of ductwork system.

K. Installation: Install metal ductwork in accordance with SMACNA HVAC Duct Construction Standards.

L. Temporary Closure: At ends of ducts which are not connected to equipment or air distribution devices at time of ductwork installation, provide temporary closure of polyethylene film or other covering which will prevent entrance of dust and debris until time connections are to be completed.

3.3 INSTALLATION OF DUCT TAKE-OFF FITTINGS:

A. Fully seal all joints.

B. Sheet metal screw regulator arm to duct after balance is complete. Mark and date position of regulator arm.
C. Insulation over regulator arm is not required.

3.4 INSTALLATION OF DUCT LINER:

A. General: Install duct liner in accordance with SMACNA HVAC Duct Construction Standards.

3.5 INSTALLATION OF FLEXIBLE DUCTS:

A. Maximum Length: For any duct run using flexible ductwork, do not exceed 5' - 0". Flex duct shall be supported every 3'-0" regardless of total length.

B. Installation: Install in accordance with Section III of SMACNA's, "HVAC Duct Construction Standards, Metal and Flexible". Duct shall be secured to collars with metal bands.

3.6 GREASE EXHAUST DUCTS:

A. Install in accordance with International Mechanical Code, NFPA 96, and local modifications to those codes. Connect to hoods in accordance with the hood manufacturer's listing.

B. Horizontal duct less than 75 feet in one run shall be pitched at 1/4" per foot towards the hood or a drain point. Those portions over 75 feet shall be pitched at 1" per foot.

C. See drawings for enclosure requirements.
   1. See other Divisions for shaft wall enclosure systems.
   2. Install duct so a minimum of 3" and a maximum of 12" is maintained between duct and enclosure.

D. Use no turning vanes, tie rods, dampers or other internal structures which will collect grease. All changes in direction shall be made with radiused fittings.

E. Provide cleanouts as follows:
   1. Cleanouts shall be installed in the side or top of the duct, whichever is more accessible.
   2. When installed on the side, the bottom of the opening shall be a minimum of 1-1/2" above the bottom of the duct.
   3. Ducts serving hoods with integral fire dampers shall have a clean out opening with 18" of the collar.
   4. Horizontal ducts shall either have one opening large enough for personnel entrance or minimum 12" x 6" openings at 12' intervals.
   5. Vertical ducts shall either have one opening at the top large enough for personnel entrance and descent or a minimum 12" x 6" openings at every floor.
   6. Openings shall have a flanged frame, extending 1" off the duct wall. Closure panels shall be attached to the flange by means of threaded studs welded to the flange, protruding through holes in the panel and fastened by means of wing nuts. Provide "Fiber Frax" or equivalent high temperature (1500°F) rope type gasket bonded to either the gasket or panel.
   7. Provide access doors in the enclosure at all cleanouts.
      a. Use UL listed fire rated access doors in shaft wall enclosures. See Section 15050.
3.7 FIELD QUALITY CONTROL:

A. Leakage Tests: Conduct duct leakage test in accordance with SMACNA HVAC Air Duct Leakage Test Manual. Repair leaks and repeat tests until total leakage is less than the maximum permissible leakage as specified below all new.

B. General:

1. Ductwork pressure tests shall be observed by Architect/Engineer prior to installation of insulation.

2. Ductwork systems in 3” W.G. pressure class and higher shall be tested in their entirety for leaks. Arbitrary sections of ductwork in 2” W.G. and lower pressure class shall be tested as required by Architect/Engineer.

3. Test Failures: Duct systems shall be repaired if test pressure and leakage requirements are not met or if air noise condition is encountered. Repairs and sealing shall be done with sheet metal, tape, sealant or a combination thereof.

C. Test Equipment:

1. Portable rotary type blower or tank type vacuum cleaner with control damper. Equipment shall have sufficient capacity to properly test reasonably large duct system section.

2. Orifice assembly consisting of straightening vanes and calibrated orifice plate mounted in a straight tube with properly located pressure taps.

3. Two (2) U-tube manometers, one to measure drop across calibrated orifice and one to measure S.P. in duct being tested. Provide low differential pressure Dwyer magnehelic gauges for low leak testing in lieu of U-tube manometers.

4. Provide Dwyer magnehelic gauge with 0-.25” W.C. range for testing 0% leakage ductwork.

D. Testing Pressures and Permissible Leakage:

1. Test pressure shall be equal to the construction class. Negative pressure duct shall be tested at the equivalent positive pressure.

2. Allowable leakage shall be determined from the following equation (or figure 4-1 in the above referenced Standard):

\[
F = C_L (P)^{0.65}
\]

Where: 
- \( F \) = Allowable leakage factor CFM/100 Sq. Ft.
- \( C_L \) = Leakage Class
- \( P \) = Test pressure inches W.C.

3. Leakage class shall be as follows:

   a. Seal class A, Round or oval duct, \( C_L = 3 \).
   b. Seal class A, Rectangular duct, \( C_L = 6 \).
   c. Seal class B, Round or oval duct, \( C_L = 6 \).
   d. Seal class B, Rectangular duct, \( C_L = 12 \).
   e. Seal class C, Round or oval duct, \( C_L = 12 \).
   f. Seal class C, Rectangular duct, \( C_L = 24 \).
4. Record all tests using the procedure and forms in the above referenced standard.

5. All plenums and casings shall be tested by pressuring to the pressure class indicated and visually observing leakage and panel deflection.
   a. No noticeable leakage shall be allowed.
   b. Deflection shall be less than 1/8" per foot.

6. Kitchen exhaust shall be leak tested at 4 S.P. at 0% leakage.

3.8 EQUIPMENT CONNECTIONS:
   A. General: Connect metal ductwork to equipment as indicated, provide flexible connection for each ductwork connection to equipment mounted on vibration isolators, and/or equipment containing rotating machinery. Provide access doors where required for service, maintenance and inspection of ductwork accessories. See section 15910.

3.9 ADJUSTING AND CLEANING:
   A. Contractor may submit alternative cleaning plan to the requirements stated below to show the ductwork will be kept clean and document the installation will meet the requirements of LEED.
   B. Clean ductwork internally, unit by unit as it is installed, of dust and debris. Clean external surfaces of foreign substances. Where ductwork is to be painted clean and prepare surface for painting.
   C. Protection:
      1. Store duct a minimum of 4" above ground or floor to avoid damage from weather or spills.
      2. Cover all stored ducts to protect from moisture, dust and debris.
      3. Maintain a cover on all ends of installed ductwork at all times, except when actually connecting additional sections of duct.
   D. Ductwork contaminated or damaged above "shop" or "mill" conditions shall be cleaned, repaired or replaced to the Engineer's satisfaction.
      1. Ductliner pre-installed in stored duct which has become wet may be installed if first allowed to completely dry out.
      2. Ductliner in installed ductwork which has become wet must be completely removed and replaced.
      3. Torn ductliner may be repaired by coating with adhesive if damage is minor and isolated. Extensively damaged liner shall be replaced back to a straight cut joint.
   E. Strip protective paper from stainless ductwork surfaces, and repair finish wherever it has been damaged.
   F. Balancing: Refer to Division-23 section "Testing, Adjusting, and Balancing" for air distribution balancing of metal ductwork; not work of this section. Seal any leaks in ductwork that become apparent in balancing process.
3.10 INSPECTION:

A. After completion of the ductwork installation, and after the Test and Balancing work, a minimum of 10% of the installed length of the supply duct system shall be inspected by an independent company specializing in such work. Inspection shall be performed using fiber optic video equipment and other appropriate techniques.

1. Sections to be inspected shall be determined by the Engineer.

B. A report, including a recording on DVD of the video shall be submitted to the engineer. The report shall document the findings of the inspection, listing any areas of concern, including evidence of water, dust, dirt and construction debris.

C. If, in the opinion of the Engineer and the Inspection Company, the supply ductwork is unacceptably contaminated, the supply duct system shall be cleaned. Additional inspections shall be performed, including sections not previously inspected. This process shall be repeated until, in the opinion of the Engineer, the supply duct system is acceptably clean.

END OF SECTION 23 31 13
SECTION 23 33 00
DUCTWORK ACCESSORIES

PART 1 - GENERAL

1.1 QUALITY ASSURANCE:

A. Manufacturer’s Qualifications: Firms regularly engaged in manufacture of ductwork accessories, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Industry Standards: Comply with ASHRAE recommendations pertaining to construction of ductwork accessories, except as otherwise indicated.

C. UL Compliance: Construct, test, and label fire dampers in accordance with UL Standard 555 “Fire Dampers and Ceiling Dampers” and U.L. Standard 555S “Motor-Driven Fire/Smoke Dampers.”

D. NFPA Compliance: Comply with applicable provisions of NFPA 90A “Air Conditioning and Ventilating Systems”, pertaining to installation of ductwork accessories.

E. SMACNA Compliance: All exhaust ducts comply with "Fire Damper and Heat Stop Guide”.

F. All fire dampers, smoke dampers, fire/smoke dampers and radiation dampers shall meet the latest local building code requirements.

1.2 SUBMITTALS:

A. Product Data: Submit manufacturer’s technical product data for each type of ductwork accessory, including dimensions, capacities, and materials of construction; and installation instructions.

B. Shop Drawings: Submit manufacturer's assembly-type shop drawings for each type of ductwork accessory showing interfacing requirements with ductwork, method of fastening or support, and methods of assembly of components. Include details of construction equipment and accessories being provided.

C. Submittals for all damper types specified in this section shall include a schedule for each damper indicating net free area, actual face velocity and pressure drop (at sea level) based on net free area & the maximum air quantity which will be passing through the damper. Submittals without this information will be rejected.

D. Record Drawings: At project closeout, submit record drawings of installed systems products, in accordance with requirements of Division 23.

E. Maintenance Data: Submit manufacturer's maintenance data including parts lists for each type of duct accessory. Include this data, product data, and shop drawings in maintenance manual; in accordance with requirements of Division 23.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Manufacturer: Subject to compliance with requirements, provide products by one of the following:

1. Dampers:
a. Greenheck  
b. AWV  
c. Air Balance, Inc.  
d. Anemostat  
e. Arrow Louver and Damper; Div. of Arrow United Industries, Inc.  
f. Louvers & Dampers, Inc.  
g. Penn Ventilator Co.  
h. Ruskin  

2. Fire Dampers and Smoke Dampers:  
   a. Greenheck  
   b. Air Balance, Inc.  
   c. Phillips Industries, Inc. Conaire Division  
   d. Ruskin  
   e. Nailor  

3. Turning Vanes:  
   a. Aero Dyne Co.  
   b. Airsan Corp.  
   c. Barb-Aire  
   d. Duro Dyne Corp.  
   e. Environmental Elements Corp.; Subs. Koppers Co., Inc.  

4. Duct Hardware:  
   a. Ventfabrics, Inc.  
   b. Young Regulator Co.  
   c. Duro-Dyne Corp.  

5. Duct Access Doors:  
   a. Kess  
   b. Greenheck  
   c. Flexmaster  
   d. Cesco-Advanced Air  
   e. Duro Dyne Corp.  
   f. Ventfabrics, Inc.  

6. Flexible Connections:  
   a. Duro Dyne Corp.  
   b. Ventfabrics, Inc.  
   c. General Rubber Corp. (Process & Exhaust Only)  

2.2 MANUAL VOLUME DAMPERS:  

A. Low Pressure Rectangular Dampers (less than 2000 FPM and under 2” W.C. S.P. Differential):  
   1. For 12” in height or larger, use multiple opposed blade type and close fitted to ducts. The frame  
      and blades shall be constructed of 16 ga. galvanized steel with plated steel shaft mounted with  
      synthetic bearings. Linkage shall be in-jamb fixed type located outside the airstream made of  
      plated steel tie bar and crank plates, with stainless steel pivots. Damper panels shall not exceed  
      48” wide. Provide jack shafting when duct size required is greater than 48” wide. Provide
notched shaft end indicating damper position, locking quadrant to fix damper position and handle. Provide stand off bracket for insulated ducts. For flat oval and round ductwork, provide type C housing.

2. For ducts less than 12" in height, frame shall be 18 ga. blade galvanized steel, steel axle with synthetic bearings locking quadrant handle and notched shaft end indicating damper position. Provide stand off bracket for insulated ducts.

B. Low Pressure Round Dampers (less than 1800 FPM and under 1" W.C. S.P. differential):
1. For low pressure spin-in fitting dampers serving individual returns/diffusers, see 23 31 13.
2. Dampers 4" diameter through 18" diameter shall be 20 ga. galvanized steel frame and blade, utilize multi-blade square dampers with transitions for ducts over 18" diameter.
   Axle shaft shall be plated steel with retainers mounted on synthetic bearings with notched end shaft indicating damper position, locking quadrant and handle. Provide stand off brackets for insulated ducts.
   a. Greenheck M80R-50 or approved equivalent.

C. Medium Pressure Rectangular Dampers (less than 4000 FPM and under 6" W.C. (48" wide or less) S.P. or 8" W.C. S.P. (36" wide or less)):
1. Dampers shall be opposed blade for volume control and parallel blade for isolation/shut-off service.
2. Frame shall be 16 ga. galvanized steel with welded corners or 1/8" thick 6063-T5 alloy aluminum frame. Blades shall be double skin galvanized steel with single-lock seam, or .081" thick 6060-T5 extruded aluminum, airfoil shape. Blade edge seals shall be vinyl, silicone, or other approved synthetic and metallic compression seals at the jambs. Axles shall be hexagonal or square plated steel mounted on bronze oilite or synthetic (ACETAL) bearings. Linkage shall be in-jamb type located outside the airstream. Maximum damper size shall be 48" wide and 60" high. For isolation or shut-off duty, damper leakage shall not exceed 9.5 CFM/Ft² at 4" W.C. S.P. differential. Provide extended shaft with notched end indicating damper position, locking quadrant and handle. Provide stand off brackets for insulated ducts.

D. Medium Pressure Round and Flat Oval Dampers (less than 3000 FPM and under 4" W.C. S.P. differential):
1. Damper frame construction shall be galvanized steel as follows:

   **ROUND**

   Under 6" dia. ........................................................................................................ 12 Gauge
   6" to 18" dia.................................................................14 Gauge

   **FLAT OVAL**

   6" to 12" wide.............................................................2 x 1/2 x 14 gauge channel
   13" to 48" wide........................................................... 2 x 1/2 x 1/8 channel
2. Damper blades shall be galvanized steel as follows:

**ROUND**

4" to 18" diameter ......................................................................................................................... 12 Gauge

**FLAT OVAL**

4" to 18" Wide ................................................................................................................................. 12 Gauge

3. Axles shall be 1/2" diameter plated steel up to 18" diameter and 18" wide flat oval, and 3/4" diameter plated steel over 18". Stainless sleeve bearings pressed in to the frame.

4. Provide notched end shaft to indicate damper position, locking quadrant and lever handle. Provide stand off bracket for insulated duct.

5. For isolation or shut-off service dampers shall be provided with edge seals with a leakage rate not to exceed 7 CFM/ft$^2$ at 1" W.C. S.P. differential (based on 18" diameter).

E. Dampers in stainless steel duct shall be of equivalent construction to the above dampers, with all components made of stainless steel. Type 304 or 316 as specified for the ductwork.

F. Dampers in aluminum duct shall be of equivalent construction to the above dampers, with all components made of either aluminum or stainless steel.

2.3 **COUNTERBALANCED PRESSURE RELIEF DAMPERS:**

A. For velocities less than 3000 FPM and under 2" W.C. S.P. differential provide dampers with parallel blades, counterbalanced and factory-set, field adjustable, to relieve at indicated static pressure. Construct blades of 16 ga. aluminum, provide 1/2" diameter ball bearings, 1/2" diameter steel axles spaced on 9" centers. Construct frame of 2" x 1/2" x 1/8" steel channel for face areas 25 sq. ft. and under; 4" x 1-1/4" x 16 ga. channel for face areas over 25 sq. ft. Provide galvanized steel finish on frame with aluminum touch-up.

2.4 **FIRE DAMPERS:**

A. Fabricated Fire Dampers: Provide dampers constructed in accordance with SMACNA "Fire Damper and Heat Stop Guide."

B. Fire Dampers: Provide dynamic rated type B or C fire dampers except as noted on drawings. Construct sleeve of galvanized steel with bonded red acrylic enamel finish, gauge as required by the listing. All fire dampers shall be UL labeled. Provide fusible link rated at 160 to 165 deg. F (71 to 74 deg. C) unless otherwise indicated. See architectural drawings for the separations and listings. Provide horizontal mounted fire damper with positive lock in closed position, and with the following additional features:

C. Damper Blade Assembly: Curtain Type.

D. Blade Material: Galvanized steel.

E. Provide integral sleeve type G fire dampers for sidewall air devices terminating at fire rated walls. Ruskin DIBD20-G or equivalent.
2.5 SMOKE DAMPERS:

A. Rectangular Motor-Driven Smoke Dampers: Frame constructed of 16-ga. steel, type 304 stainless steel side seals, silicone edge seals, bronze oilite or stainless steel sleeve bearings, airfoil shaped galvanized steel formed interlocking blades, with factory mounted actuator motor, motor mounting bracket. Out of air stream plated steel linkage.

1. Ruskin Model SD-60 or approved equivalent.

B. Round Motor-Driven Smoke Dampers 18" and Under: Frame constructed of 20 gauge galvanized steel, 2 layers of galvanized steel butterfly blade equivalent to 14 gauge, silicone rubber seal sandwiched between blade layers. Stainless steel sleeve bearings pressed into frame.

1. Ruskin SDR-25 or approved equivalent.

2. Use rectangular damper with smooth square/round transitions for dampers over 18" round.

C. Temperature Class 250°F.

D. Factory sleeve.

E. Factory mounted 24V/120V spring return electric actuator.

F. Electric Damper Actuators:

1. Actuator shall have microprocessor based motor controller providing:
   
   a. Electronic cut off at full open so that no noise can be generated while holding open. Holding noise level shall be inaudible.
   
   b. Shall be incapable of burning out if stalled before full rotation is reached.

2. Housing shall be steel and gears shall be permanently lubricated.

3. The actuators shall be direct coupled and employ a steel toothed clamp for connecting to damper shafts. Aluminum clamps or set-screw attachment are not acceptable.

4. Actuator shall have UL555S Listing by the damper manufacturer for a temperature equal to the damper.

5. Actuators shall draw no more than .23A at 120V or 24V running, or .1A holding at 120V or 24V (27 VA and 10 VA respectively for 24V power) for 70 in-# of torque.

6. Actuator shall carry a manufacturer’s 5-year warranty and be manufactured under ISO 9001 quality control

7. Damper actuators shall be Belimo Aircontrols FSLF (30 in-#) or FSNF (70 in-#).

G. Where indicated on drawings, or where required by the sequence of controls, provide factory mounted blade position switches to indicate fully open and fully closed.

H. Damper actuator shall fail close upon loss of power.

I. UL 555S & Class II.

2.6 COMBINATION FIRE/SMOKE DAMPERS:

A. Rectangular Fire/Smoke Dampers: 16 gauge galvanized steel frame, type 304 stainless steel side seals, combination silicone/galvanized steel edge seals, bronze oilite or stainless steel sleeve bearings, airfoil shaped galvanized steel parallel acting blades, square or horizontal plated steel axles, out of airstream
in-jamb linkage with stainless steel pivots, factory sleeve, caulked and attached to damper in accordance with UL fire damper requirements.

1. Ruskin FSD-60 or approved equivalent.

2. Ruskin FSD-60V or approved equivalent where axles must be vertical.

B. Round Fire/Smoke Dampers 18" Diameter and Smaller: 20 gauge galvanized steel frame/integral sleeve, 2 layer galvanized steel butterfly blade equivalent to 14 gauge, silicone rubber seal sandwiched between blade layers, stainless steel sleeve bearings pressed into frame, retaining plates in accordance with the UL listing.

1. Ruskin FSDR-25 or approved equivalent.

2. Use rectangular damper with smooth square/round transitions for dampers over 18".

C. Paint sleeve with red enamel finish.

D. Provide factory mounted spring return 120V/24V electric actuator and electric heat actuated manual reset release device. The damper shall at all times be connected to the actuator. The damper closure shall be controlled to not less than 7 seconds and no more than 15 seconds. Release device shall be set at 165°F, unless otherwise noted. Replaceable, fusible elements are not acceptable. Actuator shall be suitable for 20 psi control air.

E. Electric Damper Actuators:

1. Actuator shall have microprocessor based motor controller providing:
   a. Electronic cut off at full open so that no noise can be generated while holding open. Holding noise level shall be inaudible.
   b. Shall be incapable of burning out if stalled before full rotation is reached.

2. Housing shall be steel and gears shall be permanently lubricated.

3. The actuators shall be direct coupled and employ a steel toothed clamp for connecting to damper shafts. Aluminum clamps or set-screw attachment are not acceptable.

4. Actuator shall have UL555S Listing by the damper manufacturer for a temperature equal to the damper.

5. Actuators shall draw no more than .23A at 120V or 24V running, or .1A holding at 120V or 24V (27 VA and 10 VA respectively for 24V power) for 70 in-# of torque.

6. Actuator shall carry a manufacturer’s 5-year warranty and be manufactured under ISO 9001 quality control.

7. Damper actuators shall be Belimo Aircontrols FSLF (30 in-#) or FSNF (70 in-#).

F. Where indicated on the drawings or indicated in the sequence of control, provide factory mounted blade position switches to indicate fully open and fully closed.

G. Damper actuator shall fail close upon loss of power/control air.

H. 1 1/2 hour or 3 hour rating as required by construction type.

I. UL 555, 555S, Class II, 250°F.
J. Suitable for vertical or horizontal mounting.

K. Leakage not greater than 10 CFM per square foot at 1” W.C. pressure differential.

2.7 TURNING VANES:
A. Fabricated Turning Vanes: Provide fabricated 22 gauge, single blade 4-1/2” radius, 3-1/4” spacing turning vanes and type 2, 4-1/2” wide runners, constructed in accordance with SMACNA "HVAC Duct Construction Standards" Fig 2.3.

B. Turning vanes as a part of PVC coated air systems shall be PVC coated.

C. Do not use trailing edge turning vanes.

D. Provide intermediate support rails if length of valves exceeds 36”.

2.8 DUCT HARDWARE:
A. General: Provide duct hardware, manufactured by one manufacturer for all items on project, for the following:

B. Test Holes: Provide in ductwork at fan inlet and outlet, and elsewhere as indicated, duct test holes, consisting of slot and cover, for instrument tests.

C. Quadrant Locks: Provide for each manual volume damper, quadrant lock device on one end of shaft; and end bearing plate on other end for damper lengths over 12”. Provide extended quadrant locks and end extended bearing plates for externally insulated ductwork.

2.9 DUCT ACCESS DOORS:
A. Access Doors for Low Pressure Rectangular Duct: Construct of same or greater gauge as ductwork served, provide double wall insulated doors for insulated ductwork. Exposed insulation adhered to door is not acceptable. Provide flush frames for uninsulated ductwork, extended frames for externally insulated duct. All access doors shall have gasket and will be air tight. Provide one side hinged, other side with one handle-type latch for doors 12” high and smaller, 2 handle-type latches for larger doors. Where a hinged door can not be fully opened a removable door may be used.

B. Access Doors for Medium and High Pressure Rectangular Duct: Insulated double wall round door and frame arranged for "Spin-In" installation, with continuous gasket in frame for door. Leakage of less than .5 cfm at 6” W.G. Flexmaster "Inspector Series Spin Door" or equivalent.

C. Access Doors for Round Duct 20” and Less: Sandwich type door, constructed of an insulated double wall outer door connected to gasketed inner plate carriage bolts with hand knobs, and formed to fit the radius of the duct. Ductmate "Sandwich" or equivalent.

D. Access Door for Round Duct Greater Than 20": 18” round insulated double wall access door in gasketed frame, attached to duct section similar to tee fitting.

E. Access Doors for Flat Oval Duct: Use door specified for medium and high pressure rectangular duct in flat portion, use door specified for round duct in curved portion.
F. All access doors in exhaust system shall have inside duct surface PVC coated or at the Contractor's option.

2.10 FLEXIBLE CONNECTIONS:

A. General: Provide flexible duct connections wherever ductwork connects to vibration isolated equipment. Construct flexible connections of neoprene-coated flameproof fabric crimped into duct flanges for attachment to duct and equipment. Make airtight joint. Provide adequate joint flexibility to allow for thermal, axial, transverse, and torsional movement, and also capable of absorbing vibrations of connected equipment. Shelf life shall be verified to not exceed six (6) months. Any sign of cracking on interior or exterior shall be cause for replacement immediately.

B. Use the following product types for each application accordingly:

1. Indoor Equipment Non-Corrosive Air Systems: Heavy glass fabric, double-coated with DuPont's NEOPRENE, non-combustible fabric, fire retardant coating with good resistance to abrasion and flexing. Fabric shall be 30 oz per square yard, capable of operating at -10°F to 200°F, waterproof, air tight, 6 inches wide, complies with NFPA 90 and UL Standard #214. "Ventglas" Model as manufactured by VentFabric, Inc.

2. Outdoor Equipment Non-Corrosive Air Systems (exposed to weather and sun): Heavy glass fabric, double-coated with DuPont's HYPALON, non-combustible fabric, fire retardant coating with superb resistance to sunlight, ozone and weather which has documented 20-year-old exposure tests. Fabric shall be 26 oz per square yard, capable of operating at -10°F to 250°F, waterproof, air tight, 6 inches wide, complies with NFPA 90 and UL Standard #214. "Ventlon" Model as manufactured by VentFabrics, Inc.

3. Indoor Corrosive Air System: Heavy glass fabric coated with DuPont's teflon fluorocarbon resins, capable of operating between temperatures of -20°F and 500°F. Fabric shall be 14 oz per square yard, watertight, air tight, chemically resistant to most chemicals including but not limited to sulfuric acid, acetic acid, chlorine, dimethyl ether, xylene, hexane, ozone, nitric acid, butyl acetate, ammonia gas and liquid, acetone, mercury, cyclohexane, methanol, 6 inches wide "Ventel" model as manufactured by VentFabrics, Inc.

4. Outdoor Corrosive Air Systems: Composite a 2-layer flexible duct connection using 1 layer Vent Fabrics Ventlon (sun-resistant) and 1 layer of VentFabrics Ventel (corrosion resistant), installing the Ventlon exposed to the weather and the Ventel exposed to air stream.

PART 3 - EXECUTION

3.1 INSPECTION:

A. Examine areas and conditions under which ductwork accessories will be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to the Engineer.

3.2 INSTALLATION OF DUCTWORK ACCESSORIES:

A. Install ductwork accessories in accordance with manufacturer's installation instructions, with applicable portions of details of construction as shown in SMACNA standards, and in accordance with recognized industry practices to ensure that products serve intended function.

B. Install turning vanes in square or rectangular 90 deg. elbows in supply, return and exhaust air systems, and elsewhere as indicated.

C. Install access doors to open against system air pressure, with latches operable from either side, except outside only where duct is too small for person to enter.
D. Coordinate with other work, including ductwork, as necessary to interface installation of ductwork accessories properly with other work.

E. Provide duct access doors whether shown or not for inspection and cleaning upstream of all coils, return air turning vanes, general building exhaust turning vanes, fans, automatic dampers, fire dampers (minimum 16" x 24" in ducts larger than 18"), fire/smoke dampers, duct smoke detectors and elsewhere as indicated. Review locations prior to fabrication. Provide multiple access doors for large ductwork to provide adequate reach to equipment.

F. Install fire dampers and smoke dampers in accordance with manufacturers instructions.

G. Provide fire dampers and smoke dampers at locations shown, where ducts and outlets pass through fire rated components, and where required by authorities having jurisdiction.

H. Provide balancing dampers at points on low pressure supply, return, and exhaust systems where branches are taken from larger ducts and as required for air balancing.

I. Provide balancing dampers on high pressure systems where indicated. Use splitter dampers only where indicated on Drawings.

J. Provide flexible connections immediately adjacent to equipment in ducts associated with fans and equipment subject to forced vibration. Provide matching flanged backing frame with flexible connector where flanged fan connections are provided.

3.3 COORDINATION:

A. Coordinate with installers of other work to ensure that operators, reset devices, and fusible links are accessible at all fire, smoke, and fire/smoke dampers.

B. Show access space on coordination drawings. Locate over lay-in ceilings and above corridors wherever practical.

C. Order right/left/top/bottom arrangement as required to minimize field modifications.

3.4 FIELD QUALITY CONTROL:

A. Operate installed ductwork accessories after installation to demonstrate compliance with requirements. Test for air leakage while system is operating. Repair or replace faulty accessories, as required to obtain proper operation and leakproof performance.

B. After installation, test every fire and fire/smoke damper for proper operation, provide letter to the Architect/Engineer certifying this work is complete and all dampers are functioning properly.

3.5 ADJUSTING AND CLEANING:

A. Adjusting: Adjust ductwork accessories for proper settings, install fusible links in fire dampers and adjust for proper action.

B. Label access doors in accordance with Division-15 section "Mechanical Identification".

C. Final positioning of manual dampers is specified in Division-15 section "Testing, Adjusting, and Balancing".

D. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.
E. Touch up all scratches in PVC coated surfaces with respective coating finish.

3.6 EXTRA STOCK:

A. Furnish extra fusible links to Owner, one link for every 10 installed of each temperature range; obtain receipt.

END OF SECTION 23 33 00
PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. Extent of air terminals work required by this section is indicated on drawings and schedules, and by requirements of this section.

B. Types of air terminals specified in this section include the following:
   1. Central Air Terminals
      a. Shutoff Single Duct
      b. Reheat

C. Refer to other Division 23 sections for related work in addition to the requirements of this section.

D. Refer to Division-26 sections for the following work; not work of this section.
   1. Power supply wiring from power source to power connection on air terminals. Include disconnects, and required electrical devices, except where specified as furnished, or factory-installed, by manufacturer.

E. Provide the following electrical work as work of this section, complying with requirements of Division-16 sections:
   1. Control wiring between field-installed controls and air terminals.
      a. Control wiring specified as work of Division-15 for Automatic Temperature Controls is work of that section.

1.2 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacturer of air terminals with characteristics, sizes, and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Codes and Standards:
   1. ADC Compliance: Provide air terminals, which have been tested and rated in accordance with ADC standards, and bear ADC Seal.
   2. ARI Compliance: Provide air terminals, which have been tested and rated in accordance with ARI 880 "Industry Standard for Air Terminals" and bear ARI certification seal. Hot water coils shall be tested and rated in accordance with ARI Standard 410.
   3. NFPA Compliance: Construct air terminals using acoustical and thermal insulations complying with NFPA 90A "Air Conditioning and Ventilating Systems".
   4. UL Compliance: Construct in compliance with UL Standard 181.
   5. ASTM Compliance: Meet the Bacteriological Standards of ASTM C665.
1.3 **SUBMITTALS:**

A. Product Data: Submit manufacturer's technical product data, including performance data for each size and type of air terminal furnished; schedule showing drawing designation, room location, number furnished, model number, size, and accessories furnished; and installation and start-up instructions.

B. Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating dimensions, weight loadings, required clearances, and methods of assembly of components.

C. Wiring Diagrams: Submit ladder-type wiring diagrams for electric power and control components, clearly indicating required field electrical connections.

D. Record Drawings: At project closeout, submit record drawings of installed systems products, in accordance with requirements of Division 15.

E. Maintenance Data: Submit maintenance data and parts list for each type of air terminal; including "trouble-shooting" maintenance guide. Include this data, product data, shop drawings, and maintenance data in maintenance manual; in accordance with requirements of Division 15.

1.4 **DELIVERY, STORAGE, AND HANDLING:**

A. Deliver air terminals wrapped in factory-fabricated fiberboard type containers. Identify on outside of container type of air terminal and location to be installed. Avoid crushing or bending and prevent dirt and debris from entering and settling in boxes.

B. Store air terminals in original cartons and protect from weather and construction work traffic. Where possible, store indoors; when necessary to store outdoors, store above grade and enclose with waterproof wrapping.

**PART 2 - PRODUCTS**

2.1 **MANUFACTURERS:**

A. Manufacturer: Subject to compliance with requirements, provide products by one of the following:

1. Non-Lab Air Terminals:
   b. Anemostat Products Div.; Dynamics Corp. of America.
   c. Tempmaster
   d. Carnes Co.
   e. Carrier
   f. Trane (The) Co.
   g. Metal-Aire
   h. Krueger

2. Laboratory Air Terminals:
   a. Phoenix

2.2 **NON-LAB AIR TERMINALS:**

A. General: Provide factory-fabricated and tested air terminals as indicated, selected with performance characteristics which match or exceed those indicated on schedule.
B. Air terminal units shall be low pressure drop, single duct throttling type pressure independent and suitable for use in medium pressure variable volume air distribution systems.

C. Casing shall be minimum 22 gauge galvanized steel construction with internal acoustical coated 1/2" thick, 1-1/2 lb. density fiberglass insulation and inlet and outlet duct connections. Provide gasketed and insulated access doors for air terminals with internally mounted serviceable components, including actuators and fan motors.

D. Internal damper blade shall be extruded aluminum or 18 gauge steel with keyed fit shaft and nylon bushing. Damper shall seal against gasketed stops maximum 2% leakage at 3.0" S.P. All mechanical parts shall be galvanized or non-ferrous. Alternate damper design as produced by the Trane Company as acceptable.

E. Hot water heating coils shall be designed for 200 psig maximum working pressure and 200°F maximum operating temperature. Coil shall be serpentine-type, constructed of 1/2" O.D. copper tubes mechanically bonded to aluminum fins; galvanized steel casing.

F. Provide between terminal casing and reheat coil, factory-installed framed duct access door complete with quarter-turn quick release fasteners.

G. Provide label on each air terminal unit, indicating plan designation, unit size, cfm range and settings and calibration curve.

H. Provide a pressure independent pneumatic cross or ring-shaped flow sensor with velocity pressure pickup points for measuring inlet airflow. The sensor shall maintain control accuracy with the same size inlet duct in any configuration. Single point hot wire anemometer or straight line pneumatic sensors are not acceptable. Provide gauge ports in flow sensor tubing.

2.3 LAB CONSTANT VOLUME AND VARIABLE AIR TERMINALS:

A. General: Provide factory-fabricated and tested air terminals as indicated, selected with performance characteristics which match or exceed those indicated on schedule as manufacture by Phoenix or approved equal.

B. Air terminal units shall be low pressure drop, single duct/throttling type pressure independent and suitable for use in medium pressure air distribution systems.

C. Construction:

1. The airflow control device for non-corrosive airstreams such as supply and general exhaust shall be constructed of 16 gauge aluminum. The device’s shaft and shaft support brackets shall be made of 316 stainless steel. The pressure independent springs shall be a spring grade stainless steel. All shaft bearing surfaces shall be made of Teflon or Celenex composite. All supply devices will be externally pre-insulated at the factory, except for constant volume devices which have stand-offs for field insulation.

2. The airflow control devices shall be pressure independent venturi valves.
   a. Supply air boxes are constant air volume.
   b. General exhaust boxes are constant air volume.
   c. Biosafety cabinet exhaust boxes are constant air volume.

D. Provide between terminal casing and reheat coil field installed framed duct access door complete with quarter-turn quick release fasteners. Also, provide access door after re-heat coil.
E. Provide label on each air terminal unit, indicating plan designation, unit size, cfm range and settings, calibration curve and room served.

F. Certification:
   1. Each airflow control device shall be factory calibrated to the job specific airflows as detailed on the plans. This calibration shall account for job site elevation.

G. All airflow control devices shall be individually marked with device specific, factory calibrated data. As a minimum, it should include: tag number, serial number, model number and quality control inspection numbers. All information shall be stored by the manufacturer for use with as-built documentation.

2.4 CONTROLS:
   A. Air terminal unit manufacturer shall mount DDC controller and pneumatic actuator provided by temperature control manufacturer. See Controls Section.

   B. Velocity controllers shall have a constant reset span regardless of minimum and maximum cfm setpoints. Span must be adjustable from 3-10 psi. Reset start point must be adjustable from 3-13 psi. Each controller shall be field convertible for direct or reverse acting without re-calibration. Acceptable controllers are the TITUS II, Kreuter CSC 3004, or Kreuter CSC 3011 with reversing relay and selector switch. Total air consumption for controls shall not exceed 1.2 SCFH.

   C. All pneumatic tubing (from velocity probe) shall be UL listed fire retardant (FR) type. Each terminal shall be equipped with labeling showing unit location, size, minimum and maximum cfm setpoints, damper fail position, and thermostat action.

   D. Control devices shall be factory set and calibrated for operation with direct acting/reverse acting room thermostat.

PART 3 - EXECUTION

3.1 INSPECTION:
   A. Examine areas and conditions under which air terminals are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 COORDINATION:
   A. The contractor is responsible for determining the position of controls, actuators, and access. Coordinate each air terminal's position with building elements, piping, conduit, ductwork and other items, order left/right hand units as required and inform all other trades as required. Relocate interfering items or terminal as required to provide proper access if not coordinated beforehand.

3.3 INSTALLATION OF AIR TERMINALS:
   A. General: Install air terminals as indicated, and in accordance with manufacturer's installation instructions.

   B. Location: Install each unit level and accurately in position indicated in relation to other work; and maintain sufficient clearance for normal service and maintenance, but in no case less than that recommended by manufacturer. All hot water coils shall have access for cleaning.
C. Duct Connections: Connect ductwork to air terminals in accordance with Division-15 ductwork sections.

3.4 FIELD QUALITY CONTROL:

A. Upon completion of installation and prior to initial operation, test and demonstrate that air terminals, and duct connections to air terminals, are leak-tight.

B. Repair or replace air terminals and duct connections as required to eliminate leaks, and retest to demonstrate compliance.

3.5 CLEANING:

A. Clean exposed factory-finished surfaces. Repair any marred or scratched surfaces with manufacturers touch-up paint.

3.6 BALANCING:

A. Balancing contractor shall set all air quantity limits, and shall not rely on any factory calibration. Report air quantity as measured by the air terminals velocity pressure pick up, in addition to pitot traverses and outlet readings.

END OF SECTION 23 36 00
PART 1- GENERAL

1.1 DESCRIPTION OF WORK:

A. Extent of air outlets and inlets work is indicated by drawings and schedules, and by requirements of this section.

B. Types of air outlets and inlets required for project include the following:

Ceiling air diffusers.
Wall registers and grilles.
Louvers.

C. Refer to other Division 23 sections for ductwork, duct accessories; testing and balancing; not work of this section.

1.2 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of air outlets and inlets of types and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Codes and Standards:

1. ARI Compliance: Test and rate air outlets and inlets in accordance with ARI 650 "Standard for Air Outlets and Inlets".

2. ASHRAE Compliance: Test and rate air outlets and inlets in accordance with ASHRAE 70 "Method of Testing for Rating the Air Flow Performance of Outlets and Inlets".

3. ADC Compliance: Test and rate air outlets and inlets in certified laboratories under requirements of ADC 1062 "Certification, Rating and Test Manual".

4. ADC Seal: Provide air outlets and inlets bearing ADC Certified Rating Seal.

5. AMCA Compliance: Test and rate louvers in accordance with AMCA 500 "Test Method for Louvers, Dampers and Shutters".

6. AMCA Seal: Provide louvers bearing AMCA Certified Rating Seal.

7. NFPA Compliance: Install air outlets and inlets in accordance with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems".

1.3 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data for air outlets and inlets including the following:

1. Schedule of air outlets and inlets indicating drawing designation, room location, number furnished, model number, size, and accessories furnished.
2. Data sheet for each type of air outlet and inlet, and accessory furnished; indicating construction, finish, and mounting details.

3. Performance data for each type of air outlet and inlet furnished, including aspiration ability, temperature and velocity traverses, throw and drop, and noise criteria ratings. Indicate selections on data.

B. Samples: Submit 3 samples of each type of finish furnished.

C. Shop Drawings: Submit manufacturer's assembly-type shop drawing for each type of air outlet and inlet, indicating materials and methods of assembly of components.

D. Record Drawings: At project closeout, submit record drawings of installed systems products, in accordance with requirements of Division 23.

E. Maintenance Data: Submit maintenance data, including cleaning instructions for finishes, and spare parts lists. Include this data, product data, and shop drawings in maintenance manuals; in accordance with requirements of Division 23.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Deliver air outlets and inlets wrapped in factory-fabricated fiber-board type containers. Identify on outside of container type of outlet or inlet and location to be installed. Avoid crushing or bending and prevent dirt and debris from entering and settling in devices.

B. Store air outlets and inlets in original cartons and protect from weather and construction work traffic. Where possible, store indoors; when necessary to store outdoors, store above grade and enclose with waterproof wrapping.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Manufacturer: Subject to compliance with requirements, provide products by one of the following:

1. Diffusers, Registers and Grilles:
   a. Anemostat Products Div.; Dynamics Corp. of America.
   b. Price
   c. Carnes Co.; Div. of Wehr Corp.
   d. Krueger; Div. of Philips Industries, Inc.
   e. Titus Products Div.; Philips Industries, Inc.
   f. Metal-Aire
   g. Tuttle and Bailey

2. Louvers:
   a. Air Balance
   b. Airstream
   c. American Warming & Ventilating, Inc.
   d. Arrow United Industries, Inc.
   e. Louvers & Dampers, Inc.
   f. Penn Ventilator Co., Inc.
   g. Ruskin
   h. Greenheck
2.2 CEILING AIR DIFFUSERS:

A. General: Except as otherwise indicated, provide manufacturer's standard ceiling air diffusers where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and as required for complete installation.

B. Performance: Provide ceiling air diffusers that have, as minimum, temperature and velocity traverses, throw and drop, and noise criteria ratings for each size device as listed in manufacturer's current data.

C. Ceiling Compatibility: Provide diffusers with border styles that are compatible with adjacent ceiling systems, and that are specifically manufactured to fit into ceiling modules with accurate fit and adequate support. Refer to general construction drawings and specifications for types of ceiling systems, which will contain each type of ceiling air diffuser.

D. Types: Provide ceiling diffusers of type, capacity, and with accessories and finishes as listed on air device schedule.

2.3 REGISTERS AND GRILLES:

A. General: Except as otherwise indicated, provide manufacturer's standard registers and grilles where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and as required for complete installation.

B. Performance: Provide registers and grilles that have, as minimum, temperature and velocity traverses, throw and drop, and noise criteria ratings for each size device as listed in manufacturer's current data.

C. Wall Compatibility: Provide registers and grilles with border styles that are compatible with adjacent wall systems, and that are specifically manufactured to fit into wall construction with accurate fit and adequate support. Refer to general construction drawings and specifications for types of wall construction, which will contain each type of wall register and grille.

D. Types: Provide registers and grilles of type, capacity, and with accessories and finishes as listed on air device schedule.

2.4 LOUVERS:

A. General: Except as otherwise indicated, provide manufacturer's standard 4" deep X 4" height stationary, stormproof blade type louvers with aluminum bird screen where shown; of size indicated; constructed of aluminum and components as indicated, and as required for complete installation as scheduled.

B. Performance: Provide louvers that have a minimum of 50% free area, and a maximum pressure drop through the free area of not more than 0.075" for each type as listed in manufacturer's current data.

C. Substrate Compatibility: Provide louvers with frame and sill styles that are compatible with adjacent substrate, and that are specifically manufactured to fit into construction openings with accurate fit and adequate support, for weatherproof installation. Refer to general construction drawings and specifications for types of substrate, which will contain each type of louver.

D. Materials: Construct of aluminum extrusions, ASTM B 221, Alloy 6063-T52. Weld units or use stainless steel fasteners.

E. Louver Screens: On inside face of exterior louvers, provide 1/2" square mesh anodized aluminum wire bird screens mounted in removable extruded aluminum frames.
PART 3 - EXECUTION

3.1 INSPECTION:
   A. Examine areas and conditions under which air outlets and inlets are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION:
   A. General: Install air outlets and inlets in accordance with manufacturer's written instructions and in accordance with recognized industry practices to insure that products serve intended functions.
   B. Coordinate with other work, including ductwork and duct accessories, as necessary to interface installation of air outlets and inlets with other work.
   C. Locate ceiling air diffusers, registers, and grilles, as indicated on general construction "Reflected Ceiling Plans". Unless otherwise indicated, locate units in center of acoustical ceiling modules.

3.3 SPARE PARTS:
   A. Furnish to Owner, with receipt, 3 operating keys for each type of air outlet and inlet that require them.

END OF SECTION 23 37 13
PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. Extent of air cleaning work required by this section is indicated on drawings and schedules, and by requirements of this section.

B. Types of air cleaning equipment specified in this section include the following:
   1. Air Filters.
   2. Filter Holding Systems.
   3. Filter Gauges.

C. Refer to other Division 23 air handling units section for filter boxes and filters associated with air handling units; duct accessories section for duct access door work required in conjunction with air filters; not work of this section.

D. Refer to Division 26 sections for the following work; not work of this section.
   1. Power supply wiring from power source to power connection on air filter units. Include disconnects and required electrical devices, except where specified as furnished, or factory-installed, by manufacturer.

E. Provide the following electrical work as work of this section, complying with requirements of Division-26 sections:
   1. Control wiring between field-installed controls, indicating devices, and air filter unit control panels.
      a. Control wiring specified as work of Division 23 for Automatic Temperature Controls is work of that section.

1.2 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of air cleaning equipment of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Codes and Standards:
   1. NFPA Compliance: Comply with applicable portions of NFPA 90A and 90B, and NEC pertaining to installation of air filters and associated electric wiring and equipment.
   2. UL Compliance: Comply with UL Standards pertaining to safety and performance of air filter units.
   3. ASHRAE Compliance: Comply with provisions of ASHRAE Standard 52 for method of testing, and for recording and calculating air flow rates.
   4. ARI Compliance: Comply with provisions of ARI Standard 850 pertaining to test and performance of air filter units.
1.3 **SUBMITTALS:**

A. Submit product data, shop drawings, and wiring diagrams as specified in Division 23.

B. Samples: Submit one sample filter cartridge for each type of filter required; in accordance with requirements of Division-1.

**PART 2 - PRODUCTS**

2.1 **ACCEPTABLE MANUFACTURERS:**

A. Manufacturer: Subject to compliance with requirements, provide products by one of the following:

1. **Air Filters and Housings:**
   a. Farr Corp.
   b. Flanders Filters, Inc.
   c. Eco Air
   d. American Air Filter
   e. Grainger
   f. Ulok Fiberbond
   g. MSA
   h. Weber
   i. Barneby-Sutcliffle

2.2 **AIR FILTERS:**

A. **Pleated Media Filters:** Provide factory-fabricated, flat panel, dry, pleated, surface filters with holding frames; where shown, in sizes indicated with UL Class 1, self-extinguishing, high loft, non-woven, cotton/synthetic, media material formed into 2" deep radial pleats, supported by an expanded metal or wire mesh, in a die cut moisture resistant fiber board frame. Provide filters with rated face velocity of 500 fpm, initial resistance of 0.30" w.g. with an average 25-30% efficiency, base on ASHRAE Test Standard 52 with 90-95% dustspot efficiency, final rated resistance of 1.00" w.g., and average arrestance of 94-96%.

B. **Medium-Efficiency Cartridge-Type Filters:** Medium efficiency, extended surface, supported pleat type mounted in a 16 gauge galvanized steel holding frame. Media shall be pleated continuous fiberglass with aluminum separators. Media shall be 90-95 efficiency (ASHRAE Dust Spot 52-76) at rated capacity. Provide filters with rated face velocity of 500 fpm, initial resistance of 0.45 w.g. and final resistance of 1.0" to 1.5" w.g.

C. **High Efficiency Particulate Air (HEPA-) Filters:** Provide factory-fabricated, cartridge-type high efficiency particulate air filters with holding casing; where shown, in sizes indicated. Provide glass fiber media, rated UL Class 1 and with efficiency of not less than 99.97%, when tested with 0.3 micron particles in accordance with MIL-F-51068, and with static pressure drop of not greater than 1.0" w.g., when clean and operating at rated capacity. Equip filters with gaskets and construct media of continuous sheets with closely spaced pleats separated by corrugated aluminum inserts. Construct holding casing of 18-ga galvanized steel, complete with gaskets and holding latches and capable of being bolted together, or held with retainers, to form filter bank with airtight joints. Construct downstream corners of holding device with cushion pads to protect media. Provide filters 11-1/2" deep with rated face velocity of 250 fpm, initial operating resistance of 1.0" w.g., and recommended final resistance of 3.0" w.g.
2.3 FILTER HOLDING SYSTEMS:

A. Side Servicing Housings: Provide factory-assembled side servicing housings with flanges for insertion into ductwork system as indicated. Construct of 16-ga galvanized steel. Provide integral pre-filter tracks to accommodate 2” throw-away or cleanable filters. Provide access doors with continuous gasketing on perimeter and positive locking devices. Incorporate positive-sealing gasket material on channels to seal top and bottom of filter cartridge frames to prevent bypass. Arrange so filter cartridges can be loaded from either access door.

1. Leak-test housing by pressurizing to 3” w.g. and soap-bubble test housing joints, door seals, and filter sealing edges. Provide crank-operated spring-loaded filter-sealing mechanism with limit stop, so geared that total pressure of 600 lbs. will be exerted on each filter. Design clamping frame to provide continuous knife-edge seal for all four edges of each individual filter.

2.4 FILTER GAUGES:

A. Manufacturer:

1. Dwyer

B. Direct Reading Dial: 4-3/4 inch OD diaphragm actuated dial in metal case, vent valves, black figures on white background, front recalibration adjustment, appropriate ranges of 0.05, 0-1.0, 0-2.0, 0-3.0 or 0-4.0 inch WG; 2 percent of full scale accuracy; Magnehelic Series 2000 manufactured by Dwyer.

C. Accessories: Static pressure tips with integral compression fittings, ¼ inch aluminum tubing, 2-way or 3-way vent valves.

D. Inclined Manometer: Not acceptable.

PART 3 - EXECUTION

3.1 INSPECTION:

A. Examine areas and conditions under which air filters and filter housings will be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION:

A. General: Comply with installation requirements as specified elsewhere in these specifications pertaining to air filters housing/casings, and associated supporting devices.

B. Install air filters and holding frame devices of types indicated, and where shown; in accordance with air filter manufacturer's written instructions and with recognized industry practices; to ensure that filters comply with requirements and serve intended purposes.

C. Locate each filter unit accurately in position indicated, in relation to other work. Position unit with sufficient clearance for normal service and maintenance.

D. Anchor filter holding frames securely to substrate. Provide intermediate steel support bars between every other column of frames on filters high, or as recommended by manufacturer.

E. Coordinate with other work including ductwork and air handling unit work, as necessary to interface installation of filters properly with other work.
F. Install filters in proper position to prevent passage of unfiltered air. Seal between each filter frame and filter frame and plenum housing airtight.

G. Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.

1. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division-16 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment Installer.

H. Install air filter gauge pressure tips upstream and downstream of filters to indicate air pressure drop through air filter. Mount filter gauges on outside of filter housing or filter plenum, in accessible position. Adjust and level inclined gauges if any, for proper readings.

3.3 FIELD QUALITY CONTROL:

A. Operate installed air filters to demonstrate compliance with requirements. Test for air leakage of unfiltered air while system is operating. Correct malfunctioning units at site, then retest to demonstrate compliance; otherwise remove and replace with new units, and proceed with retesting.

3.4 EXTRA STOCK:

A. Provide one complete extra set of filters for each air handling system. If system is designed to include pre-filters and after-filters, provide both types of filters only pre-filters. Install new filters at completion of air handling system work, and prior to testing, adjusting, and balancing work. Obtain receipt from Owner that new filters have been installed.

END OF SECTION 23 41 00
SECTION 23 51 00
BREECHINGS, CHIMNEYS, AND STACKS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Listed chimney liners.
2. Listed double-wall vents.
3. Listed, refractory-lined breechings and stacks.
4. Field-fabricated metal breechings.
5. Listed grease and dishwasher ducts.
6. Barometric Dampers

1.2 SUBMITTALS

A. Product Data: For the following:

1. Chimney liners.
2. Type B and BW vents.
3. Type L vents.
4. Special gas vents.
5. Building-heating-appliance chimneys.
7. Refractory-lined metal breechings and chimneys.
8. Guy wires and connectors.
9. Barometric Dampers

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, methods of field assembly, anchoring requirements, expansion compensation, pressure relief devices, components, hangers and seismic restraints, and location and size of each field connection.

2. For installed products indicated to comply with design loads, include calculations required for selecting seismic restraints and structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

C. Welding certificates.
D. Manufacturer Seismic Qualification Certification: Submit certification that factory-fabricated breeching, chimneys, and stacks; accessories; and components will withstand seismic forces defined in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
   b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Breeching, Chimneys, and Stacks: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of anchorage devices on which the certification is based and their installation requirements.

E. Warranty: Special warranty specified in this Section.

F. Vent System Sizing Calculations: Computer calculated sizing analysis for the boilers and/or water heaters being furnished. The computer analysis shall include the make, model number, firing rate and allowable back pressure for each vented appliance. The analysis shall also include drawing detailing the vent system layout including lengths, number of fittings and sizes. Where applicable expansion calculations and expansion joint selection shall also be included.

1.3 QUALITY ASSURANCE

A. Source Limitations: Obtain listed system components through one source from a single manufacturer.


C. Certified Sizing Calculations: Manufacturer shall certify venting system sizing calculations.

1.4 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

1.5 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of venting system that fail in materials or workmanship within specified warranty period. Failures include, but are not limited to, structural failures caused by expansion and contraction.

1. Warranty Period: 10 years from date of Substantial Completion.
PART 2 - PRODUCTS

2.1 LISTED SPECIAL GAS VENTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Heat-Fab, Inc.
   2. Metal-Fab, Inc.
   3. Selkirk Inc.; Selkirk Metalbestos and Air Mate.
   4. Schebler

B. Description: Double-wall metal vents tested according to UL 1738 and rated for 480 deg F continuously, with positive or negative flue pressure complying with NFPA 211.

C. Construction: Inner shell and outer jacket separated by at least a 1/2-inch airspace.

D. Inner Shell: ASTM A 959, Type 29-4C stainless steel.

E. Outer Jacket: Aluminized steel.

F. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.
   1. Termination: Stack cap designed to exclude minimum 90 percent of rainfall.
   2. Termination: Round chimney top designed to exclude minimum 98 percent of rainfall.
   3. Termination: Exit cone with drain section incorporated into riser.

2.2 LISTED BUILDING-HEATING-APPLIANCE CHIMNEYS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. American Metal Products; MASCO Corporation.
   2. Hart & Cooley, Inc.
   3. Metal-Fab, Inc.
   4. Selkirk Inc.; Selkirk Metalbestos and Air Mate.
   5. Simpson Dura-Vent Co., Inc.; Subsidiary of Simpson Manufacturing Co.
   6. Van-Packer Company, Inc.

B. Description: Double-wall metal vents tested according to UL 103 and rated for 1000 deg F continuously, or 1700 deg F for 10 minutes; with neutral or negative flue pressure complying with NFPA 211.

C. Construction: Inner shell and outer jacket separated by at least a 2-inch annular space filled with high-temperature, ceramic-fiber insulation.

D. Inner Shell: ASTM A 666, Type 304 stainless steel.

E. Outer Jacket: Aluminized steel.
F. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.

1. Termination: Stack cap designed to exclude minimum 90 percent of rainfall.
2. Termination: Round chimney top designed to exclude minimum 98 percent of rainfall.

2.3 **GUISING AND BRACING MATERIALS**

A. Cable: Three galvanized, stranded wires of the following thickness:

1. Minimum Size: 1/4 inch in diameter.
2. For ID Sizes 4 to 15 Inches: 5/16 inch.
3. For ID Sizes 18 to 24 Inches: 3/8 inch.
4. For ID Sizes 27 to 30 Inches: 7/16 inch.
5. For ID Sizes 33 to 36 Inches: 1/2 inch.
6. For ID Sizes 39 to 48 Inches: 9/16 inch.
7. For ID Sizes 51 to 60 Inches: 5/8 inch.


C. Angle Iron: Three galvanized steel, 2 by 2 by 0.25 inch.

2.4 **BAROMETRIC DAMPERS**

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Field Controls L.L.C.; Venting Solutions Company (The).


**PART 3 - EXECUTION**

3.1 **EXAMINATION**

A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of work.

1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 **APPLICATION**

A. Listed Chimney Liners: High-efficiency boiler or furnace vents in masonry chimney, dishwasher exhaust, or Type II commercial kitchen hood.

B. Listed Type B and BW Vents: Vents for certified gas appliances.

C. Listed Type L Vent: Vents for low-heat appliances.
D. Listed Special Gas Vent: Condensing gas appliances.


F. Listed Grease Ducts: Type I commercial kitchen grease duct.


H. Field-Fabricated Metal Breechings and Chimneys: Dual-fuel boilers, oven vents, water heaters, exhaust for engines, fireplaces, and other solid-fuel-burning appliances.

I. Field-Fabricated Metal Breechings and Chimneys: Steel pipe for use with engine exhaust.

3.3 INSTALLATION OF LISTED VENTS AND CHIMNEYS

A. Locate to comply with minimum clearances from combustibles and minimum termination heights according to product listing or NFPA 211, whichever is most stringent.

B. Seal between sections of positive-pressure vents and grease exhaust ducts according to manufacturer's written installation instructions, using sealants recommended by manufacturer.

C. Support vents at intervals recommended by manufacturer to support weight of vents and all accessories, without exceeding appliance loading.

D. Slope breechings down in direction of appliance, with condensate drain connection at lowest point piped to nearest drain.

E. Lap joints in direction of flow.

F. Connect base section to foundation using anchor lugs of size and number recommended by manufacturer.

G. Join sections with acid-resistant joint cement to provide continuous joint and smooth interior finish.

H. Erect stacks plumb to finished tolerance of no more than 1 inch out of plumb from top to bottom.

3.4 INSTALLATION OF BAROMETRIC DAMPERS:

A. Secure barometric dampers to breechings with hardware compatible with connected materials.

B. Locate barometric dampers as close to appliance outlet as possible.

3.5 CLEANING

A. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

B. Clean breechings internally, during and after installation, to remove dust and debris. Clean external surfaces to remove welding slag and mill film. Grind welds smooth and apply touchup finish to match factory or shop finish.

C. Provide temporary closures at ends of breechings, chimneys, and stacks that are not completed or connected to equipment.

END OF SECTION 23 51 00
PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. Extent of terminal unit work is indicated on drawings and schedules, and by requirements of this section.

B. Types of terminal units required for project include the following:

2. Finned tube radiation.
3. Convector.
4. Unit heaters.
5. Cabinet unit heaters.
6. Fan-coil units.
7. Coils.
8. Radiant-acoustical ceiling panels (hot water).

C. Refer to other Division 23 sections for piping; ductwork; testing, adjusting and balancing of terminal units; not work of this section.

D. Refer to Division 26/1 section for the following work; not work of this section.

1. Power supply wiring from power source to power connection on terminal units.

2. Provide the following electrical work as work of this section, complying with requirements of Division 26 sections:
   a. Control wiring between field-installed controls, indicating devices, and terminal unit control panels.
   1) Control wiring specified as work of Division 23 for Automatic Temperature Controls is work of that section.

E. Refer to other Division 23 sections for automatic temperature controls not factory installed, required in conjunction with terminal units; not work of this section.

1.2 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of terminal units, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Codes and Standards:

1. I=B=R Compliance: Test and rate baseboard and finned tube radiation in accordance with I=B=R, provide published ratings bearing emblem of I=B=R.

2. ARI Compliance: Provide coil ratings in accordance with ARI Standard 410 "Forced-Circulation Air-Cooling and Air-Heating Coils".

3. ASHRAE Compliance: Test coils in accordance with ASHRAE Standard 33 "Methods of Testing Forced Circulation Air Cooling and Heating Coils".
4. ARI Compliance: Test and rate fan-coil units in accordance with ARI Standard 440 "Room Fan-Coil Air Conditioners".

5. UL Compliance: Construct and install fan-coil units in compliance with UL 883 "Safety Standards for Fan Coil Units and Room Fan Heater Units".

6. UL Compliance: Provide electrical components for terminal units, which have been listed and labeled by UL.

7. ARI Compliance Test and rate unit ventilators in accordance with ARI Standard 330 "Unit Ventilators".

8. AGA Compliance: All gas fired heating equipment shall be AGA Design Certified.

9. Electric Heating Equipment: All equipment with a heating coil capacity exceeding a 48 amp rating shall have the heating elements subdivided and protected by an overcurrent protection device rated at not more than 60 amps. Equipment not exceeding 48 amps shall also have overcurrent protection. Overcurrent protection devices shall be factory wired and installed in accordance with the National Electric Code. All equipment shall be factory assembled and wired in accordance with the National Fire Protection Association and shall be listed by Underwriters' Laboratories.

1.3 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data, for terminal units showing dimensions, capacities, ratings, performance characteristics, gauges and finishes of materials, and installation-startup instructions.

B. Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating terminal unit dimensions, weight loading, required clearances, construction details, field connection details and methods of assembly of components.

C. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to terminal units. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

D. Record Drawings: At project closeout, submit record drawings of installed systems products in accordance with requirements of Division 23.

E. Samples: Submit 3 samples of each type of cabinet finish furnished.

F. Maintenance Data: Submit maintenance instructions, including lubrication instructions, filter replacement, motor and drive replacement, control, accessories, "trouble-shooting" maintenance guide, and spare parts lists. Include this data, product data, and shop drawings in maintenance manuals; in accordance with requirements of Division 23.

1.4 DELIVERY, STORAGE, AND HANDLING:

A. Handle terminal units and components carefully to prevent damage, breaking, denting and scoring. Do not install damaged terminal units or components; replace with new.

B. Store terminal units and components in clean dry place. Protect from weather, dirt, fumes, water, construction debris, and physical damage.
C. Comply with Manufacturer's rigging and installation instructions for unloading terminal units, and moving them to final location.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Manufacturer: Subject to compliance with requirements, provide products by one of the following:

1. Baseboard Radiation
   a. Slant/Fin Corp.
   b. Vulcan
   c. Sterling Radiator; Div. of Reed National Corp.
   d. Trane
   e. Weil-McLain, Marley Co.

2. Finned Tube Radiation
   a. Dunham-Bush, Inc.
   b. Vulcan
   c. Sterling Radiator; Div. of Reed National Corp.
   d. Trane
   e. Rittling
   f. Rose Mex

3. Convectors
   a. Vulcan
   b. Dunham-Bush, Inc.
   c. Trane
   d. Airtherm
   e. Rittling
   f. Rose Mex
   g. Sterling

4. Unit Heaters
   b. Vulcan
   c. McQuay Inc.
   e. Trane
   f. Rittling
   g. Rose Mex
   h. Sterling

5. Cabinet Unit Heaters
   b. McQuay Inc.
   c. Trane
   d. Vulcan
   e. Modine
   f. Rittling
   g. Rose Mex
6. Fan Coil Units
   b. Corp.
   c. Dunham-Bush, Inc.
   d. McQuay Inc.
   e. Trane
   f. York; Div. of York International
   g. International Fan Coil
   h. Airtherm
   i. Carrier
   j. Heatcraft
   k. Pace
   l. Rose Mex

7. Coils:
   a. Aerofin Corp.
   b. Corp.
   c. Dunham-Bush, Inc.
   d. McQuay Inc.
   e. Trane (The) Co.
   f. York; Div. of York International

2.2 BASEBOARD RADIATION:
   A. General: Provide (hot water) (steam) (electric) baseboard radiation of lengths, wall to wall enclosure, in locations as indicated, of capacities, style, and having accessories as scheduled.
   B. Cabinets: Minimum 20-ga cold-rolled steel, one-piece back and top panel, front panel with integral damper. Provide steel brackets inserted in back/top panel, to support element and front panel. Provide standard/custom/prime coat baked enamel finish on topside and front panel only.
   C. Elements: Copper tube and aluminum fins, with slide mechanism between element and support brackets to eliminate expansion and contraction noises.
   D. Accessories: Provide the following accessories:
      1. End panels, inside and outside corners, and enclosure extensions.
      2. Removable 18" long cover access section in front of valves, balancing cocks, and traps.
      3. Factory-mounted dampers.
      4. Sill extensions.
      5. Mullion channels.
      6. Pilaster covers.

2.3 FINNED TUBE RADIATION:
   A. General: Provide (hot water) (steam) finned tube radiation of lengths, wall to wall enclosure, in locations as indicated, of capacities, style, and having accessories as scheduled.
   B. Cabinets: Minimum 16 ga. cold-rolled steel, continuous 20-ga. partial height/full height backplate, minimum 16/18/14 ga. front. Brace and reinforce front minimum of 4'-0" o.c. without visible fasteners.
C. Elements: Copper tube and aluminum fins, with tube mechanically expanded into fin collars to eliminate noise and ensure durability and performance at scheduled ratings.

D. Finish: Unfinished zinc coated steel/flat black heat resisting paint backplate, standard factory color selected baked enamel finish/custom color as selected by Architect in baked enamel finish on front, sides, top and accessories.

E. Accessories:
   1. End panels, inside and outside corners, and enclosure extensions.
   2. Hinged cover access section in front of valves, balancing cocks, and traps. Install after piping and covers are in place.
   3. Factory-mounted dampers.
   4. Sill extensions.
   5. Mullion channels.
   6. Pilaster covers.

2.4 CONVECTORS:

A. General: Provide hot water/steam convectors having cabinet sizes and in locations as indicated, and of capacities, style, and having accessories as scheduled.

B. Cabinets: Minimum 16-ga steel front and top panels, 18-ga side panels, and 20-ga back panels. Phosphatize and galvanize back panels, phosphatize and standard/custom/ color baked enamel finish top, sides, and front, with one coat of primer. Secure fronts in place with quick opening slide bolts or camlock fasteners.
   1. Recessed Cabinets: One-piece front panel, with 4-side gasketed overlap.
   2. Non-recessed cabinets shall have sloping tops.
   3. End caps waffle butted to walls and on exposed ends.

C. Elements: Aluminum fins, ribbed steel side plates, fin tube supports and copper tubes, cast-iron headers. Factory-test each element to 150 psi air pressure under water.

D. Accessories: Provide the following accessories:
   1. Factory-mounted dampers.
   2. 1/2" insulation on cabinet back.
   3. Access doors in front for valve access.

2.5 UNIT HEATERS:

A. General: Provide unit heaters in locations as indicated, and of capacities, style, and having accessories as scheduled.

B. Horizontal Unit Heaters:
C. Vertical Unit Heaters:
   1. Casings: Construct of steel, phosphatized inside and out, and finished with standard color baked enamel finish. Design casing to enclose fan, motor, and coil, design fan orifice formed into discharge panel. Provide air diffusers as scheduled.
   2. Fans: Construct of aluminum and factory-balance. Design so motor and fan assembly is removable through fan outlet panel.

D. Coils: Construct of plate-type aluminum fins, mechanically bonded to copper tubes. Design coil for use in steam/hot water applications.

E. Motors: Provide totally enclosed motors, with built-in overload protection, having electrical characteristics as scheduled.

2.6 CABINET UNIT HEATERS:
   A. General: Provide hot water/steam cabinet heaters having cabinet sizes and in locations as indicated, and of capacities, style, and having accessories as scheduled. Include in basic unit chassis, coil, fanboard, fan wheels, housings, motor, and insulation.
   B. Chassis: Galvanized steel wrap-around structural frame with edges flanged.
   C. Insulation: Faced, heavy density glass fiber.
   D. Cabinet: 16-ga removable front panel, 18-ga top and side panels. Insulate front panel over entire coil section. Provide access door on coil connection side. Clean cabinet parts, benderize, phosphatize, and flow-coat with baked-on primer. Standard factory color selected baked enamel finish/Custom color as selected by Architect in baked enamel finish. Non-recessed cabinets shall have sloping tops.
   E. Water Coils: Construct of 5/8" seamless copper tubes mechanically bonded to configurated aluminum fins. Design for 300 psi and leak test at 300 psi under water. Provide same end connections for supply and return.
   F. Steam Coils: Construct of 1" seamless copper tubes mechanically bonded to configurated aluminum fins. Design for 75 psi and leak test at 450 psi under water. Provide cast-iron headers, and same end connections for supply and return.
   G. Fans: Provide centrifugal, forward curved double width fan wheels constructed of non-corrosive, molded, fiberglass- reinforced thermo-plastic material. Construct fan scrolls of galvanized steel. Fans shall be statically and dynamically balanced.
   H. Motors: Provide 3-speed motors with integral thermal over-load protection, and motor cords for plug-in to junction box in unit.
   I. Filters: Provide 1" thick permanent, cleanable type filters.
   J. Accessories: Provide the following accessories as indicated and/or scheduled:
   K. Wall Boxes: Provide aluminum wall boxes with integral eliminators and insect screen.
      1. Recessing Flanges: Provide 18-ga steel flanges for recessing cabinet heaters into wall or ceiling.
      2. Sub-bases: Provide 18-ga steel sub-base for vertical units, height as indicated.
      3. Extended Oilers: Provide plastic motor oiler tubes extending to beneath top discharge grille.
L. Controls: Provide internal 3-speed on/off switch in addition to temperature controls specified in section 15975.

2.7 FAN-COIL UNITS:

A. General: Provide fan-coil units having cabinet sizes, and in locations indicated, and of capacities, style, and having accessories as scheduled. Include in basic unit chassis, coils, fanboard, drain pan assembly, fans, housing, motor, filter, and insulation.

B. Chassis: Construct chassis of galvanized steel with flanged edges.

C. Insulation: Faced, heavy density glass fiber.

D. Cabinet: Construct of 18-ga steel removable panels, 16-ga front. Provide insulation over entire coil section. Clean cabinet parts, bonderize, phosphatize, and flow-coat with baked-on primer. Standard factory color selected baked enamel finish./ Custom color as selected by Architect in baked enamel finish.

E. Coils: Construct of 1/2” seamless copper tubes mechanically bonded to configurated aluminum fins. Design for 250 psi working pressure, and leak tested at 350 psi under water.

F. Auxiliary Heating Coils: Construct of 1/2” seamless copper tubes mechanically bonded to configurated aluminum fins. Design for 250 psi working pressure.

G. Drain Pans: Construct of galvanized steel. Insulate with polystyrene or polyurethane insulation. Provide drain connection.

H. Fans: Provide centrifugal forward curved double width wheels of reinforced fiberglass, in galvanized steel fan scrolls.

I. Motors: Provide motors with integral thermal overload protection. Run test motors at factory in assembled unit prior to shipping. Provide quickly detachable motor cords.

J. Filters: Provide 1” thick throwaway type filters in fiberboard frames.

K. Dampers: Provide 18-ga steel damper blades with polyurethane stop across entire blade length. Provide factory-mounted electric operators for 25% open cycle.

L. Accessories: Provide the following accessories as indicated and/or scheduled:

1. Wall Boxes: Provide aluminum wall boxes with integral eliminators and insect screen.

2. Discharge Grille Panels: Provide 18-ga galvanized steel, stamped integral grilles, with access doors.

3. Sub-Bases: Provide 18-ga steel sub-base, height as indicated.

4. Extended Oilers: Provide plastic motor oiler tubes extending to beneath top discharge grille.

5. Recessing Flanges: Provide 18-ga steel flanges for recessing fan-coil units into wall or ceiling.
2.8 COILS:

A. General: Provide coils of size and in location indicated, and of capacities and having performance data as scheduled. Certify coil capacities, pressure drops, and selection procedures in accordance with ARI 410. Fin spacing to be 12 fins per inch or less.

B. Heating Coils:

1. Fins: Construct of continuous aluminum or copper configurated plate-fin type with full fin collars for accurate spacing and maximum fin-tube contact.

2. Tubes: Construct of copper tubing, expanded into fin collars for permanent fin-tube bond and expanded into header for permanent leaktight joint.

3. Headers: Construct of gray cast iron for coils 33" high and smaller. Hydrostatically test to 400 psi before assembly. Construct of round seamless copper tube for coils over 33" high.

4. Casings: Construct of 16-ga continuous coated galvanized steel with fins recessed into channels to minimize air bypass.

5. Testing: Proof test coils at 300 psi, leak test at 200 psi under water.

6. Coil Types: Provide the following coil types as indicated, and as scheduled.

C. Cooling Coils:

1. Fins: Construct of continuous aluminum or copper configurated plate-fin type with full fin collars for accurate fin spacing and maximum fin-tube contact.

2. Tubes: Construct of 5/8" seamless copper tubes, arranged in parallel pattern with respect to air flow.

3. Casings: Construct of 16-ga stainless steel for coil heights 33" and smaller; 14-ga for coil heights over 33". Provide formed end supports and top and bottom channels. Provide 16-ga center tube support for coil lengths 42" to 96", 2 or more supports for coil lengths over 96".

4. Air Bypass Arrestor: Provide foam sealing strip located between casing channels and fins along top and bottom.

5. U-Bends: Construct of 5/8" copper tubes, machine die-formed on each end to provide accurate fit for silver brazed joints.
6. Testing: Proof test water coils at 300 psi and leak test at 200 psi under water. Proof test refrigerant coils at 450 psi and leak test at 300 psi under water; clean, dehydrate, and seal with dry nitrogen charge.

7. Coil Types: Provide the following coil types as indicated, and as scheduled:
   a. Cleanable and Drainable Water Coils: Provide close-grained gray cast-iron inlet, outlet, and removable headers. Bolt headers to flat steel plates with gaskets. Roll tubes into steel plates and headers.
   b. Drainable Water Coils: Provide close-grained gray cast-iron inlet, outlet, and intermediate headers.
   c. Standard Water Coils: Provide close-grained gray cast-iron inlet and outlet headers for coil heights 33” and smaller. Provide seamless copper tube headers for coil heights over 33”.
   d. Refrigerant Coils: Provide refrigerant distributor of venturi type with low pressure drop design, arranged for down feed and maximum of 12 circuits per distributor. Provide seamless copper tube suction header. Construct distributor tubes of 5/16” copper tube for R-12, 1/4” copper tube for R-22.

8. Cooling coils shall be capable of operating at face velocities up to 600 FPM without moisture carryover. Coat fins with fin coating to prevent moisture carryover. Any coils found to have excessive moisture carryover during system operation shall be corrected by the manufacturer at no cost to the Owner.

9. Evaporative Section: Provide an evaporative section, over a common pan section with the cooling coil. This section shall be constructed with the coil preceding the evaporative section in the direction of air flow. The "Munters Fill" type media is to be 12" deep, in the direction of air flow. Section is to be complete with distribution pipe and header with a connection point in the center of the header for a 3/4" copper pipe. Media is to have a saturation efficiency of 89% at 500 feet per minute face velocity.

10. Pan: The pan under the cooling coil and the evaporative section shall be 1/8” MOH HRS plate/heavy gauge 304 stainless steel continuously welded. Pan to be a minimum of 12” deep with drain coupling welded to the structural support. Finish inside of pan with three coats of zinc impregnated submarine primer (ZIPCOR) for MOH HRS.

11. Evaporative Section Casing: Provide a casing enclosure of heavy gauge galvanized iron with the inside surface painted with two coats of "ZIPCOR".

   OR

Heavy gauge 304 stainless steel.

2.9 RADIANT-ACOUSTICAL CEILING PANELS:

A. The radiant acoustical panels shall be placed into a standard grid system to be provided by the General Contractor in accordance with the Architect's reflected ceiling plans.

B. Provide 1/2” O.D., Type "L" copper loops for interconnection of panels.

C. Radiant panels shall have certified performance data provided by a recognized testing laboratory.

D. Panels shall be finished with standard white paint.
E. Provide supervision by distributor of panels.

PART 3 - EXECUTION

3.1 INSPECTION:

A. Examine areas and conditions under which terminal units are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION OF BASEBOARD RADIATION:

A. General: Install baseboard radiation as indicated, and in accordance with manufacturer's installation instructions.

B. Locate baseboard radiation on outside walls as indicated, run cover continuous wall-to-wall unless otherwise indicated.

C. Center elements under windows. Where multiple windows occur over units, divide element into equal segments centered under each window.

D. Install end caps where units butt against walls. Install access panels centered in front of each shutoff valve, balancing cock, or temperature control valve.

3.3 INSTALLATION OF FINNED TUBE RADIATION:

A. General: Install finned tube radiation as indicated, and in accordance with manufacturer's installation instructions.

B. Locate finned tube radiation on outside walls as indicated, run cover wall-to-wall unless otherwise indicated.

C. Center elements under windows. Where multiple windows occur over units, divide element into equal segments centered under each window.

D. Install end caps where units butt against walls. Install access panels centered in front of each shutoff valve, balancing cock, steam trap, or temperature control valve.

3.4 INSTALLATION OF CONVECTORS:

A. General: Install convectors as indicated, and in accordance with manufacturer's installation instructions.

B. Locate convectors as indicated, coordinate with other trades to assure correct recess size for recessed convectors.

3.5 INSTALLATION OF UNIT HEATERS:

A. General: Install unit heaters as indicated, and in accordance with manufacturer's installation instructions.

B. Uncrate units and inspect for damage. Verify that nameplate data corresponds with unit designation.

C. Hang units from building substrate, not from piping. Mount as high as possible to maintain greatest headroom possible unless otherwise indicated.
D. Support units with rod-type hangers anchored to building substrate.
E. Install piping as indicated.
F. Protect units with protective covers during balance of construction.

3.6 INSTALLATION OF CABINET HEATERS:
A. General: Install cabinet heaters as indicated, and in accordance with manufacturer's installation instructions.
B. Locate cabinet heaters as indicated, coordinate with other trades to assure correct recess size for recessed units.
C. Install piping as indicated.
D. Protect units with protective covers during balance of construction.

3.7 INSTALLATION OF FAN-COIL UNITS:
A. General: Install fan-coil units as indicated, and in accordance with manufacturer's installation instructions.
B. Locate fan-coil units as indicated, coordinate with other trades to assure correct recess size for recessed units.
C. Provide piping as detailed on the drawings.
D. Provide 3/4" condensate drain pipe from unit drain pan connection to nearest adequate floor drain or drain pipe.
E. Protect units with protective covers during balance of construction.

3.8 INSTALLATION OF COILS:
A. General: Install coils as indicated, and in accordance with manufacturer's installation instructions.
B. Mount coils on steel supports to form banks or stacks as indicated, brace, secure to air intake chamber. Place in location to permit installation of bypass damper if required, provide steel baffles where required to prevent bypassing of air.
C. Pitch coil casings for drainage, not less than 1/8" toward return connections, except where drainage feature is included in coil design.
D. Provide for each bank of cooling coils, drain pan(s) under each coil supported off of floor of sufficient height to allow installation of condensate drain pipe trap to allow drainage of condensate from pan when installed on suction side of fan. Provide condensate drain piping from drain pan connection to nearest adequate floor drain. Plug any unused drain connection.
E. Provide for each steam coil unit, steam supply connection with strainer, gate valve, automatic temperature regulating valve, condensate return connection with vacuum breaker, f & t trap, and gate valve, as indicated.
F. Provide for each hot or chilled water coil unit, water supply, return connection, strainer, gate valves, automatic temperature regulating valve, balancing cocks, as indicated.
G. Provide electric wiring for each electric duct heater in accordance with manufacturer's installation instructions and Division 26.

H. All coils shall have access for cleaning.

3.9 INSTALLATION OF RADIANT CEILING PANELS:

A. General: Install hot water radiant ceiling panels as indicated and in accordance with manufacturers’ installation instructions.

B. Inspect for damage and verify that nameplate data correspondence with panel designation.

3.10 ELECTRICAL WIRING:

A. General: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.

B. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division 26 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.

3.11 ADJUSTING AND CLEANING:

A. General: After construction is completed, including painting, clean unit exposed surfaces, vacuum clean terminal coils and inside of cabinets.

B. Retouch any marred or scratched surfaces of factory-finished cabinets, using finish materials furnished by manufacturer.

C. Install new filter units for terminals requiring same.

3.12 START-UP:

A. Start-up, test, and adjust terminal units in accordance with manufacturer's published start-up instructions. Adjust for proper airflow where applicable.

END OF SECTION 23 82 16
PART 1 - GENERAL

1.1 RESPONSIBILITY

A. The Division 21, 22, 23 and 26 contractor(s) shall comply with the provisions of this section. The Division 21, 22 and 23 and 26 contractor(s) shall verify electrical service provided by the electrical contractor before ordering any mechanical equipment requiring electrical connections. Provide submittals of all mechanical equipment to Division 26 and 28 contractor(s).

B. The final responsibility for properly coordinating the electrical work of this section shall belong to the Division 21, 22 and 23 system contractor performing the work, which requires the electrical power.

1. Each contractor shall be responsible for providing power wiring for certain devices as described in the specifications and on the drawings. This work shall be provided by a licensed electrician in accordance with all of the applicable provisions of the Division 26 and 28 specifications, NEC and local codes.

1.2 WORK INCLUDED

A. Carefully coordinate the interface between Division 21 (Fire Protection), Division 22 (Plumbing Protection) and 23 (Mechanical HVAC and Controls) and Division 26 (Electrical) and 28 (Fire Alarm) before submitting any equipment for review or commencing installation.

B. This Division of the Specifications may also be referred by other Divisions of the Specifications, or on the Contract Drawings.

1.3 DEFINITIONS

A. **Automatic**: Pertaining to a function, operation, process or device that, under specified conditions, functions without intervention by human operator.

B. **Disconnect Switch**: A mechanical switching device used for changing the connections in a circuit, or for isolating a circuit or equipment from a power source.

C. **Control Circuit/Power**: The circuit which carries the electrical signals of a control apparatus or system directing the performance of the controller but does not carry the main power circuit.

D. **Manual Operation**: Operation by hand without the use of any other power.


F. PC: Plumbing Contractor = Division 22.

G. MC: Mechanical Contractor = Division 23 Contractor who furnishes motor.

H. TC: Temperature Controls = Division 23 Contractor who furnishes control.

I. EC: Electrical Contractor = Division 26 Contractor.

J. FA: Fire Alarm Contractor = Division 28 Contractor who furnishes Fire Alarm System.
### 1.4 RESPONSIBILITY SCHEDULE

**A. Responsibility:** Unless otherwise indicated, all motors and controls for Division 23 equipment shall be furnished, set in place and wired in accordance with the following schedule:

<table>
<thead>
<tr>
<th>ITEM -</th>
<th>Furnished Under</th>
<th>Set In Place Under</th>
<th>Power Wiring Under</th>
<th>Control Wiring Under</th>
</tr>
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<tbody>
<tr>
<td>AHU Interior Marine Lights</td>
<td>MC</td>
<td>MC</td>
<td>EC</td>
<td>MC</td>
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<tr>
<td>Equipment Motors</td>
<td>MC</td>
<td>MC</td>
<td>EC</td>
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<tr>
<td>Automatically or Manually Controlled Starters/Contactors: (Note 4)</td>
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<tr>
<td>-Separate</td>
<td>MC</td>
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<td>EC</td>
<td>TC</td>
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<tr>
<td>-Factory Mounted and Wired</td>
<td>MC</td>
<td></td>
<td>MC</td>
<td>TC</td>
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<tr>
<td>Motor Speed Controllers: (Note 4)</td>
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<tr>
<td>-Separate</td>
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<tr>
<td>-Factory Mounted and Wired</td>
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<td>Disconnect Switches (Note 1)</td>
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<td>Switches (Manual or Automatic other than disconnect) (Note 2)</td>
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<td>EC or TC</td>
<td>TC or MC</td>
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<tr>
<td>Control Relays (Note 2)</td>
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<td>TC</td>
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<tr>
<td>Control Transformers</td>
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<tr>
<td>Push Button Stations</td>
<td>MC</td>
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<td>TC</td>
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<tr>
<td>Thermostat and Controls: Integral with Equipment or Directly Attached to Ducts, Pipes, etc. (Note 2)</td>
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<td>Equipment in Temperature Control Panels</td>
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<tr>
<td>Valve Motors, Damper Motors, Solenoid Valves, etc.</td>
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<tr>
<td>EP Valves or Switches, P.E. Switches, etc.</td>
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<td>Fire Alarm System (Note 3)</td>
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<td>Fire Sprinkler Alarm (Note 3)</td>
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<td>Duct System Smoke Detectors (Note 5)</td>
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<tr>
<td>Relays for Fan Control via duct detectors (Note 5)</td>
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<td>Room Smoke Detectors Including Relays for Fan Control (Note 3)</td>
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<td>CO Sensors</td>
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<td>Control Air Compressor</td>
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<td>Refrigerated Air Dryer</td>
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<tr>
<td>Equipment Interlocks</td>
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<td>Fire/Smoke and Smoke Dampers (Note 7)</td>
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<td>EC</td>
<td>FA</td>
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<tr>
<td>ITEM - Positive Indication Devices (i.e., current sensors, end switches, airflow sensors)</td>
<td>Furnished Under</td>
<td>Set In Place Under</td>
<td>Power Wiring Under</td>
<td>Control Wiring Under</td>
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<td>TC</td>
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<td>FA/TC</td>
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</tbody>
</table>

Notes:

1. If furnished as part of factory wired equipment furnished and set in place by MC, wiring and connections by EC.
2. If float switches, line thermostats, P.E. switches, time switches, or other controls carry the FULL LOAD CURRENT to any motor, they shall be furnished by MC, but they shall be set in place and connected by EC, except that where such items are an integral part of the mechanical equipment, or directly attached to ducts, piping, or other mechanical equipment, they shall be furnished and set in place by MC and connected by EC. If they do not carry the FULL LOAD CURRENT to any motor, they shall be furnished, set in place and wired by TC contractor.
3. Pre-action system initiation signals (such as smoke detectors, or general alarm conditions in a pre-action zone) shall be provided under Division 28.
4. Electrical contractor is responsible for wiring from starter to motor, unless factory wired.
5. Temperature control contractor shall provide conduit and wire from auxiliary contact in motor starter to the detector so that the unit shuts down in all operating modes. Fire Alarm Contractor to wire from detector to fire alarm panel.
6. Each division shall be fully responsible for any control panels as called for on the drawings or specifications.
7. Division 23 and 26 shall provide all power and control wiring to fire/smoke or smoke dampers along with initiation signals to temperature control panels as described in the specifications.
8. TC wiring required only when damper also serves HVAC system.
9. TC wires to components utilized in the control and monitoring of the Automated Building Control System.

B. Power Wiring by Division 23: The electrical power for certain equipment provided under Division 23 has not been specifically indicated on the electrical drawings and must be provided by and field coordinated by the Division 23 or Division 22 or Division 21, whichever trade requiring such power.

Sufficient power for this purpose shall be furnished as “spare” dedicated circuit capacity in Division 26’s panelboards. All wiring, conduit and electrical devices downstream of the panelboards is the responsibility of the Division 23 trade requires the power.

1. Such equipment is hereby defined as:
   a. Electrical heat trace. Required heat trace locations, capacities and specification are shown on the plumbing drawings.
   b. Fire protection air compressors, dry-pipe control panels and valves. Required connections are to be included in the Division 21 work, and will be shown by that contractor’s engineered system design drawings.
      1) Pre-action system initiation signals (such as smoke detectors, or general alarm conditions in a pre-action zone) shall be provided under fire alarm work.
      2) Division 21 shall provide pre-action control panel and interconnection between nearest suitable fire alarm panel and location of pre-action valve(s).
2. Temperature control panels, control air compressors and line voltage power for 24v control transformers. Required connections are included in Division 23 and will be shown by that contractor's control submittal drawings.

1.5 GENERAL REQUIREMENTS

A. Remote Switches and Pushbutton Stations:

1. Provide remote switches and/or pushbutton stations required for manually operated equipment (if no automatic controls have been provided) complete with pilot lights of an approved type lighted by current from load side of starter.

B. Special Requirements:

1. Motors, starters and other electrical equipment installed in moist areas or areas of special conditions, such as explosion proof, shall be designed and approved for installation in such areas with appropriate enclosure.

C. Identification:

1. Provide identification of purpose for each switch and/or pushbutton station furnished. Identification may be either engraved plastic sign permanently mounted to wall below switch, or stamping on switch cover proper. All such identification signs and/or switch covers in finished areas shall match other hardware in the immediate area.

D. Control Voltage:

1. Maximum allowable control voltage 120V. Fully protect control circuit conductors in accordance with National Electrical Code.

E. DDC Control Interface:

1. Fully coordinate the requirements of each division with regard to supplying a complete DDC Control System prior to submitting bid.
2. All control power shall be furnished via dedicated line voltage circuits.
3. Low voltage wiring from J-boxes to distributed control components, all low voltage connections, all control panels and all control transformers (not part of unitary equipment) shall be provided under Division 23.
4. Any additional power requirements shall be the responsibility of the Division 23 Contractor requiring same, and provided at no additional cost to the owner.

1.6 CEILING AND CHASE CAVITY PRECEDENCE

A. Coordinate ceiling cavity space carefully with all trades. In the event of conflict, install mechanical and electric systems within the cavity space allocation in the following order of precedence. A system with higher precedence may direct that systems of lower precedence be relocated from space, which is required for expedient routing of the precedent system.

1. Plumbing waste, cooling coil drain piping, and roof drain mains and leaders.
2. Steam and condensate piping.
3. Hydronic main piping (12” and larger).
4. Plumbing vent piping.
5. Supply, return and exhaust ductwork.
6. Electrical conduit greater than 4” diameter.
7. Hydronic branch and mains (greater than 2”, but less than 12”).
8. Domestic water piping.
9. Fire sprinkler mains and leaders.
10. Hydronic branch piping (2” and less).
11. Domestic hot and cold water branches.
12. Electrical conduit branch feeders.
13. Pneumatic control piping.
14. Fire sprinkler branch piping and sprinkler runouts.

B. Light fixtures have precedence in a zone, which is the same height above the ceiling as the depth of the fixture (plus 2”).

C. Examine the contract documents of all trades (e.g. all Division 21, 22, 23, 26 and 28 drawings, the architectural floor plans, reflected ceiling plans, elevations and sections, structural plans and sections, etc.).

D. Coordinate necessary equipment, ductwork and piping locations so that the final installation is compatible with the materials and equipment of the other trades.

E. Prepare shop drawings for installation of all new work before installation to verify coordination of work between trades.

F. Provide access doors for all equipment, valves, clean-outs, actuators and controls which require access for adjustment or servicing and which are located in otherwise unaccessible locations.

1. For equipment located in “accessible locations” such as lay-in ceilings: Locate equipment to provide adequate service clearance for normal maintenance without removing architectural, mechanical, electrical or structural elements such as the ceiling support system, electrical fixtures, etc. “Normal maintenance” includes, but is not limited to: filter changing; greasing of bearings; using p/t ports for pressure or temperature measurements; and replacement of ballasts, fuses, etc.

PART 2 – PRODUCTS

2.1 MOTOR HORSEPOWER

A. In general, all motors ¾ HP and above shall be three phase, all motors ½ HP or less shall be single phase.

B. Voltage and phase of motors as scheduled on the electrical drawings shall take precedence in the case of a conflict between the mechanical and electrical drawings or general condition 2.1. A., above.

C. Work under Divisions 21, 22 or 23 includes coordinating the electrical requirements of all mechanical equipment with the requirements of the work under Division 26, before ordering the equipment.

1. If motor horsepowers are changed under the work without a change in duty of the motor’s driven device, coordination of additional electrical work (if any) and additional payment for that work (if any) shall be provided under the section of that Division initiating the change. Increases or decreases in motor horsepower from that specified shall not be made without written approval from the Architect/Engineer.

PART 3 - EXECUTION - (Not Used)
END OF SECTION
SECTION 26 05 02
ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. This Section supplements Division 1, General Requirements.

B. Where contradictions occur between this Section and Division 1, the most stringent of the two shall apply. Architect shall decide which is most stringent.

C. Provisions of Divisions 21, 22, 23, 27 and 28 shall also apply to the work of this section as if fully repeated here.

D. Provision indicate Section 23 05 01/26 05 01 “Mechanical and Electrical Coordination” shall also apply to the work of this section as if fully repeated here.

1.2 REGULATORY REQUIREMENTS

A. All materials shall conform with the current applicable industry standards. Workmanship and neat appearance shall be as important as electrical and mechanical operation. Defective or damaged materials shall be replaced or repaired prior to final acceptance in a manner meeting approval of the Architect and at no additional cost to the Owner.

B. The latest editions of the following standards are minimum requirements.

1. Underwriters’ Laboratories, Inc. (UL)
2. National Electrical Manufacturer’s Assoc. (NEMA)
3. American National Standards Institute (ANSI)
4. Institute of Electrical and Electronic Engineers (IEEE)
5. International Electrical Testing Association (NETA)
6. Insulated Cable Engineer’s Association (ICEA)

C. All work and materials shall comply with latest rules, codes and regulations including, but not limited to the following:

1. OSHA.
2. National Fire Codes of National Fire Protection Assoc. (NFPA)
7. All applicable Federal, state and local laws, code amendments and regulations.

D. Code compliance is mandatory. Nothing in these drawings and specifications permits work not conforming to these codes.

E. No work shall be concealed until after inspection and approval by proper authorities. If work is concealed without inspection and approval, Contractor shall be responsible for all work required to open and restore the concealed area including all required modifications.
F. Contradictions: Where Codes are contradictory, follow the most stringent. Architect/Engineer shall determine which is most stringent.

G. This project will follow the guidelines and requirements of Leadership in Energy and Environmental Design (LEED). Provide all services and documentation as required.

1.3 CONTRACT DOCUMENTS

A. Drawings indicate general arrangement of circuits and locations of outlets, conduit, and other work. Information shown on drawings is as accurate as planning can determine, but not guaranteed and field verification of all dimensions, locations, levels, etc., to suit field conditions is directed. Review all architectural, structural, technology, lab and mechanical drawings, and adjust all work to conform to all conditions shown therein. Architectural drawings shall take precedence over all other drawings. Discrepancies between different drawings or between drawings and specifications or regulations and codes governing installation shall be brought to attention of the Architect and Engineer prior to installation.

B. Where the Drawings and Specifications do not comply with the minimum requirements of the Codes, either notify the Architect/Engineer in writing during the Bidding Period of the revisions required to meet Code requirements, or provide an installation which complies with the Code requirements. After entering into contract, Contractor will be held to complete all work necessary to meet these requirements without additional expense to the Owner.

C. Follow Drawings and Specifications where they are superior to Code requirements. The more stringent of plans and drawing shall apply.

D. The Electrical Contractor shall provide electrical work and equipment as called for in the Division 27 Specification Sections.

1. Basic Communications Requirements
2. Bidding
3. Quality Assurance
4. Common Work – Sleeves, Penetrations and Firestopping
5. Common Work – Hangers and Supports
6. Electrical – General Requirements
7. Electrical – Grounding and Bonding
8. Electrical – Conduit and boxes
9. Electrical – Cable Trays
   a. The requirements of these Sections are additional to, different from, or otherwise supplement the requirements of similar work specified in Division 26.
   b. The requirements of these Sections serve as the basis for the requirements of this Section, and are incorporated by reference into this specification Section.
10. Electrical – Underground Ducts and Raceways
11. Electrical – Maintenance and Hand holes

1.4 COORDINATION DRAWINGS

A. Prepare coordination drawings in accordance with Division 1 “Submittals” to a scale of 1/4” = 1'-0” or larger; detailing major elements, components, and systems of electrical equipment (i.e., all switchgear rooms, generator yard, electrical rooms and telephone rooms) and materials in relationship with other systems, installations, and building components. Where equipment is located outdoors, prepare shop drawings indicating electrical equipment locations and exterior elements in the equipment areas. Indicate locations where space is limited for installation and
access and where sequencing and coordination of installations are important to the efficient flow of the work, including (but not necessarily limited to) the following:

1. Indicate the proposed locations of major raceway systems, and materials. Include the following:
   a. Exterior wall and foundation penetrations.
   b. Fire-rated wall and floor penetrations.
   c. Support details.
   d. Sizes and location of required concrete pads and bases.
2. Indicate scheduling, sequencing, movement, and positioning of large equipment into the building during construction.
3. Prepare floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installation.
4. Electrical Rooms indicating conduit stub-up locations and bus riser location.
5. Cable tray floor plans and elevations showing exact routing.
7. Telephone underground conduit and duct bank routing.
8. Feeder conduit 2” and larger.

1.5 RECORD DRAWINGS

A. Refer to Division 1 for additional requirements.

B. Maintain a blue-line set of Electrical Contract Drawings in clean, undamaged condition, for mark-up of installations which vary from the Contract Drawings. These drawings shall be a separate set of drawings, not used for construction purposes, and shall be kept up to date as the job progresses. This set shall be made available for inspection by the Engineer or Architect at all times. Upon completion of the contract a set of computerized “as built” capable of interfacing with AutoCAD software, shall be delivered to the Architect.

C. Prepare record documents in accordance with the requirements in Division 1 Section “Project Closeout.” In addition to the requirements specified in Division 1, indicate installed conditions for:
   1. Major raceway systems, size and location, for both exterior and interior and locations of handholes and conduit stub-up locations.
   2. Panelboard circuit directories reflecting all field changes.
   3. Approved substitutions, Contract Modifications, and actual equipment and materials installed.
   4. Results of all testing performed as specified in the specification.
   5. Certification of inspection from Authorities Having Jurisdiction.

D. Record the locations and invert elevations of underground installations.

1.6 OPERATING AND MAINTENANCE MANUALS

A. Refer to Division 1 for additional requirements.

B. Submission:
   1. Submit three typed and bound copies of Operating and Maintenance Manuals prior to scheduling systems demonstration for the Owner.
   2. Bind each Maintenance Manual in one or more vinyl covered, 3-ring binders, with pockets for folded drawings.
      a. Mark the back spine of each binder with system identification and volume number.
C. Requirement Contents:

1. Manuals shall have index with tab dividers for each submittal section identifying all equipment and materials installed on the project including a local supplier for replacing a specific piece of equipment.
2. Provide certificates for such items of equipment which have warranties in excess of one year.
3. Provide test results for each specification section identified herein.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.

B. Protection of Equipment:

1. All electrical equipment to be used in the construction shall be properly stored and protected against the elements. All equipment shall be stored under cover, and shall not be stored at the construction site on the ground, in mud, water, rain, sleet, or dust. Large diameter cables may be stored on reels outside; however, all cable ends shall be waterproofed and the reels covered with weatherproof materials. Such weatherproof materials shall be heavy-duty, securely fastened, and made impervious to the elements.
2. Conventional electrical construction materials such as building wire, outlet and junction boxes, wiring devices, conduit, lighting fixtures, fittings, etc., shall be stored in construction buildings, covered trailers, or portable covered warehouses. Any equipment subject to damage or corrosion from excessive moisture shall be stored in dry, heated areas. Any equipment containing plastic or material subject to damage caused by excessive heat or sunlight shall be stored to prevent such damage. This includes plastic ducts and lenses.
3. Equipment damaged as a result of the above conditions shall be properly repaired at the contractor’s expense or shall be replaced at the contractor’s expense, if in the opinion of the Engineer, the equipment has been damaged to such an extent that it cannot operate properly after repairs are made.
4. All electrical enclosures exposed to construction damage such as paint spots, spackling or plaster spatter, grout splashes, waterproofing compound, tar spots or runs, and pipe covering compound splashes, shall be completely covered and protected against damage.
5. In the event leakage into the building of any foreign material or fluid occurs or may occur, the contractor shall take all steps as described above to protect any and all equipment.
6. After connections to electrical equipment are complete and the equipment is ready for operation, all construction debris shall be removed from all enclosures. Such debris includes dust, dirt, wire clippings, tape, and insulation removed in order to make the connection.

1.8 SAFETY AND INDEMNITY

A. The Contractor shall be solely and completely responsible for conditions of the job site, including safety of all persons and property during performance of the work. This requirement will apply continuously and not be limited to normal working hours. See also General Conditions.

B. No act, service, drawings review or construction review by the Architect or Engineer, is intended to include review of the adequacy of the Contractor’s safety measures in, on, or near the construction site.
1.9 WARRANTIES

A. The warranty period is generally one year after Date of Acceptance.

1. During this period, provide labor and materials as required to repair or replace defects in the electrical systems at no cost to the Owner. Provide certificate with O & M manual submittal which guarantees same day service response to the Owner’s call for such warranty service.

2. Provide certificates for such items of equipment which have warranties in excess of one year. Insert copies of O & M manual. Such equipment shall include:
   a. Emergency generator system including transfer switches and paralleling switchgear
   b. Major electrical switchgear and switchboard
   c. Electrical transformers and panelboards
   d. Enclosed bus assemblies
   e. Lighting fixtures
   f. Fire alarm system
   g. Network lighting control
   h. Central dimming control
   i. Static Uninterruptable Power Supply
   j. Heat trace cables and controls

3. Provide extended manufacturers warranties to cover one full year from Date of Acceptance if standard manufacturers’ warranty ends any time prior to that date.

PART 2 - PRODUCTS

2.1 EQUIPMENT AND MATERIALS

A. All equipment and materials installed shall be new, unless otherwise specified.

B. All major equipment components shall have manufacturers’ name, address, model number and serial number permanently attached in a conspicuous location.

C. All equipment shall be UL listed and bear the UL label.

2.2 GENERAL SUBMITTAL REQUIREMENTS

A. Coordination and Sequencing:

1. After receipt of notice to proceed, the Contractor shall submit to the Architect a typed list of submittals and the scheduled date of submission. List shall include submittal number, section number and scheduled date of submission. Submittals shall be grouped and submitted in no more than ten complete packages.

2. The contractor shall not submit any shop drawings or product data that does not comply with the contract documents. Prior to submitting shop drawings, review submittal for compliance with Contract Documents and place a stamp or other confirmation thereon which states that submittals have been reviewed. Submittals without such verification will be returned disapproved without review.

3. Submittal is for information and record, unless otherwise indicated, and is not a change order request.

B. Preparation of Submittals:

1. Refer to Division 1 requirements.
2. The Contractor shall submit for approval by the Architect data of materials and equipment to be incorporated in the work. Submittals shall be supported by descriptive material, catalogs, cuts, diagrams, performance curves, and charts published by the manufacturer to show conformance to specification and drawing requirements; model numbers alone will not be acceptable. Provide complete electrical characteristics for all equipment. Submit product submittals on items as outlined in sections hereinafter.

3. Product submittals shall be made by specification section. All items of a section, requiring submission, shall be submitted together at one time in a tabbed binder. If two or more sections require inter-coordination (e.g., emergency generator and transfer switch; short circuit study, electrical room layouts and electrical switchboards), they shall be submitted at the same time.

4. Each individual submittal items within a binder shall be marked to show section number which pertains to the item.

5. Provide permanent marking on each binder identifying project name, Contractor, Subcontractor, submittal name, date of submission, specification section, and information to distinguish it from other submittals.

6. Section binders shall be report cover type with solid cover and 3 metal fasteners. Binders shall also have a tab indicating submittal number and specification section number. If product submittals for section exceed the capacity of one binder, two or more binders shall be used. In addition, a notation cover shall indicate the number of binders for the section and number of that binder (i.e., 2 or 3). Binders shall have rigid cover and be of appropriate size.

7. Submittals not presented in a bound, neat and legible fashion will returned “Without Action.”

8. Submittals shall show Contractor’s executed review and approval marking. Submittals which are received from sources other than through Contractor’s office will be returned “Without Action.”


10. If the contractor is providing electronic submittal data, he shall also include a minimum of one hard copy of product data for the following equipment:
   a. Switchgear
   b. Switchboards
   c. Panelboards
   d. Generator
   e. UPS
   f. Low Voltage Transformers
   g. Automatic Transfer Switch
   h. Lighting Fixtures
   i. All shop drawings shall be submitted as hard copy, as required per Division 1.

C. Substitutions

1. Refer to the General Conditions, which governs “Substitution” of specified equipment or materials.

2. Indicate any portions of work which deviate from the Contract Documents.
   a. Explain the reasons for the deviations.
   b. Show how such deviations coordinate with interfacing portions of other work.

3. Where substitution of materials alters space requirements indicated on the drawings, submit shop drawings indicating proposed layout of space, all equipment to be installed therein and clearances between equipment (i.e., electrical rooms). All clearances required by the National Electrical Code and applicable state and local regulations must be maintained.
D. Review Process

1. The Architect reserves the right to require a sample of any equipment to be submitted for approval and to retain its possession.

2. Refer to the individual sections for identified equipment and material for which submittals are required. In addition, provide shop drawings and product data on the following equipment:

   - Electrical Power Conductors and Cables
   - Grounding and Bonding
   - Hangers and Supports
   - Raceway and Boxes
   - Cable Trays (Refer to Technology)
   - Underground Duct, Raceway and Manholes
   - Identification
   - Central Dimming Controls
   - Network Lighting Control
   - Low Voltage Distribution Transformers
   - Switchboards
   - Panelboards
   - Enclosed Bus Assemblies
   - Wiring Devices
   - Lightning Protection System
   - Fuses
   - Generator Sets
   - Automatic Transfer Switches
   - Transient Voltage Surge Suppression
   - Lighting Fixtures
   - Poles and Standards
   - Enclosed Switches and Circuit Breakers
   - Fire Alarm System
   - Static Uninterruptable Power Supply (UPS)

Do not submit on equipment or materials not requested in the specifications.

3. Review of shop drawings and product data by the Architect/Engineer, including any review annotations or stamp notations, does not relieve the contractor from the required compliance with the contract documents.

4. The shop drawing and product data review stamp notation requirements are defined as follows:
   a. “NO EXCEPTION TAKEN:” The reviewer did not observe any items which were not in compliance with the contract documents. All dimensions, details, and coordination with other trades is the responsibility of the contractor.
   b. “MAKE CORRECTIONS NOTED:” The reviewer indicated items observed that were not in compliance with the contract documents. The contractor shall not resubmit, but shall make corrections and provide corrected documents with the “Record Drawings.”
   c. “REJECTED, REVISE AND RESUBMIT:” The reviewer indicated items observed which were not in compliance with the contract documents. The contractor shall resubmit showing corrections of all noted items. Delays for resubmittal does not relieve the contractor from meeting project schedules.
   d. “REJECTED:” The submission does not comply with the contract requirements. The entire submittal must be corrected and submitted for review. Delays for resubmittal does not relieve the contractor from meeting project schedules.
5. If shop drawings are submitted and returned as “NO EXCEPTION TAKEN” or “MAKE CORRECTIONS NOTED” and meet contract requirements, the contractor shall not resubmit any other shop drawings for these items.

6. If resubmittals are necessary, they shall be made as specified above for submittals. Resubmittals shall highlight all revisions made and cover shall include the phrase “RESUBMITAL NO. ______________.”

Resubmittal requirements do not entitle the Contractor to additional time and are not a cause for delay of the project.

PART 3 – EXECUTION

3.1 CONDITIONS AT SITE

A. Visit to site is required of all bidders prior to submission of bid. All bidders will be held to have familiarized themselves with all discernible conditions, and no extra payment will be allowed for work required because of these conditions, whether specifically mentioned or not.

B. Lines of other services and/or equipment that are damaged as a result of this work shall promptly be repaired at no expense to the Owner.

3.2 LICENSES, FEES AND PERMITS

A. Arrange for required inspections and pay all license, permit and inspection fees. Furnish a certificate of final inspections and approvals from local authority having jurisdiction over electrical installation.

3.3 WORKMANSHIP AND CONTRACTOR’S QUALIFICATIONS

A. Only professional quality workmanship will be accepted. Haphazard or poor installation practice will be cause for rejection of work.

B. Provide foreman in charge of this work at all times. Foremen for this work shall have had experience in installing not less than 5 such electrical systems of equal or greater complexity.

C. Where specifications call for an installation to be made in accordance with manufacturers’ recommendations, a copy of such recommendations shall at all times be kept in job superintendent’s office.

3.4 RELATION WITH OTHER TRADES

A. Contractor shall coordinate work of this Division with other trades to avoid conflict and to provide rough-ins and other connections for equipment furnished under other divisions that require electrical connections. Inform other trades of required clearances of accesses for or around electrical equipment to maintain serviceability and code compliance.

B. Verify equipment dimensions and rough-in requirements for Divisions 2 through 28 with provisions specified under this Section of work, and report discrepancies to the Architect in ample time to prevent delays or unwarranted changes of work.

3.5 TESTING

A. Provide all labor, materials, and equipment necessary to make required tests. Tests shall be complete and results approved before final inspection is begun.
3.6 PROGRESS OF WORK

A. Order progress of electrical work so as to conform to progress of work of other trades, and complete entire installation as soon as condition of building will permit. Assume any cost resulting from defective or ill-timed work performed under this Division.

3.7 CUTTING AND PATCHING

A. General: Perform cutting and patching in accordance with Division 1 Section “Cutting and Patching.” In addition to the requirement specified in Division 1, the following requirements apply:

1. Perform cutting, fitting, and patching of electrical equipment and materials required to:
   a. Uncover work to provide for installation of ill-timed work.
   b. Remove and replace defective work.
   c. Remove and replace work not conforming to requirements of the Contract documents.
   d. Remove samples of installed work as specified for testing.
   e. Install equipment and materials in newly installed structures.
   f. Upon written instructions from the architect, uncover and restore work to provide for Architect observation of concealed work.

3.8 SLEEVES

A. Place sleeve in forms of walls, floor slabs and partitions for passage of all conduits, pipes, and ducts installed under Divisions 26, 27 and 28. Sleeves shall be set in place a sufficient time ahead of concrete work so as not to delay that work. Install sleeves and raceways through exterior walls so as to provide a waterproof installation. All floor penetrations shall be made watertight. Conduits passing through walls shall be installed to preserve integrity of the wall rating (i.e., fire rating, sound rating, air, etc.). All penetration made through existing concrete slabs or walls shall be x-rayed and approved by Structural Engineer prior to cutting.

3.9 EXCAVATION, TRENCHING, AND BACKFILLING

A. Perform all excavation to install conduit and duct banks indicated on the drawings or specified herein. During excavation, pile material for backfilling back from the banks of the trench to avoid overloading and to prevent slides and cave-ins. Remove and dispose of all excavated materials not to be used for backfill. Grade to prevent surface water from flowing into trenches and excavation. Remove any water accumulating therein by pumping. Do all excavation by open cut. No tunneling shall be done unless indicated on the drawings or unless written permission is received from the Architect.

B. Grade the bottom of trenches to provide uniform bearing and support for conduits or duct bank on undisturbed soil at every point along its entire length. Tamp over depths with loose, granular, moist earth. Remove unstable soil that is not capable of supporting equipment or installation and replace with specified material for a minimum of 12” below invert of equipment or installation.

C. Backfill the trenches with excavated materials approved for backfilling, consisting of earth, loam, sandy clay, sand and gravel or soft shale. These materials should be free from large clods of earth and stones, deposited in 6” layers and rammed until the installation has cover of not less than the adjacent ground but not greater than 2” above existing ground. Backfilling shall be carried on simultaneously on both sides of the trench so that injurious pressures do not occur. Compaction of the filled trench shall be at least equal to that of the surrounding undisturbed material. Do not settle backfill with water. Reopen any trenches not meeting compaction
requirements or where settlement occurs, refill, compact, and restore surface to grade and compaction indicated on the drawings, mounded over and smoothed off.

D. In addition, all excavation and backfilling shall comply with Division 2. The most stringent requirement shall apply.

3.10 CLEANUP

A. Remove all materials, scrap, etc., relative to electrical installations and leave premises in a clean, orderly condition. Any costs to the Owner for cleanup of site will be charged to the Contractor. At completion, all equipment, raceways, etc., shall be thoroughly cleaned and all residue removed from the inside and outside surfaces. Defaced finish shall be refinished.

3.11 TEMPORARY POWER

A. Provide temporary power as requested by the general contractor and in accordance with OSHA and local code requirements. Lighting and power outlets shall be provided throughout the project. Check with construction manager or general contractor prior to bid for special lighting and power outlets and provide as needed.

3.12 MINOR CHANGES

A. The Owner reserves the right to make minor changes in the locations of outlets and equipment up to the time of electrical rough-in without any cost to the Owner.

3.13 ELECTRICAL SYSTEMS OPERATIONAL TESTS, CERTIFICATION, AND DESIGN AUTHORITY ASSISTANCE

A. Testing

1. Refer to the individual specification sections for test requirements.
2. Prior to the final inspection, the systems or equipment shall be tested and reported as herein specified. Six (6) typewritten copies of the tests shall be submitted to the Architect/Engineer for approval.
3. All electrical systems shall be tested for compliance with the specifications.

B. Manufacturers’ Certifications

1. The electrical systems specified herein shall be reviewed for compliance with these specifications, installation in accordance with the manufacturers’ recommendations and system operation by a representative of the manufacturer. The manufacturer shall submit certification that the system has been installed in accordance with the manufacturers’ recommendations and is operating as specified in the contract documents.
2. Provide manufacturers’ certification for the emergency generator set/automatic transfer system, central dimming controls, network lighting control and fire alarm system.

C. Design Authority Assistance

1. The Contractor shall provide personnel to assist the Architect/Engineer or his representative during all construction review visits. The Contractor shall provide all necessary tools and equipment to demonstrate the system operation and provide access to equipment, including screwdrivers, wrenches, ladders, flashlights, circuit testing devices, meters, keys, etc.
2. Remove equipment covers (i.e., switchgears, switchboards, panelboard trims, panelboards, motor controls, device plates, and junction box covers) as directed for
inspection of internal wiring. Accessible ceiling shall be removed as directed for inspection of equipment installed above ceilings. Reinstall all covers or ceilings after inspection.

3. Energize and de-energize circuits and equipment as directed. Demonstrate operation of equipment as directed by Architect/Engineer.

4. The Contractor shall provide authorized representatives of the manufacturers to demonstrate to the Architect/Engineer compliance with the specifications of their respective system during or prior to the final inspection at a time designated by the Architect. Refer to the appropriate specification section for additional testing requirements. Representatives of the emergency generator/automatic transfer switch and fire alarm systems are required for demonstrations.

3.14 COMMISSIONING

A. After startup and testing of each system has been completed, the Owner shall have an independent firm conduct detailed observations of the equipment and systems to confirm compliance with the Contract Documents.

B. The Division 26 Contractor shall include, as part of the work of his contract, costs to cover manpower, equipment, tools, ladders, instruments, etc., necessary to expedite the system performance observations.

C. The independent firm shall develop systems, equipment checkout procedures and data forms for recording compliance of the systems to the Contract Documents, performance, and construction observation lists, and will assist in developing schedules for checkout and Owner acceptance, at a future date during the construction phase.

END OF SECTION
SECTION 26 05 03
TESTING

PART 1 - GENERAL

1.1 RELATED WORK SPECIFIED ELSEWHERE

A. Acceptance and startup testing requirements for electrical power distribution equipment and systems. Contractor shall retain and pay for the services of a recognized independent testing firm for purpose of performing inspections and tests as herein specified.

1. The testing firm shall provide all material, equipment, labor, and technical supervision to perform such tests and inspections.
2. It is the purpose of these tests to assure that all tested electrical equipment is operational and within industry and manufacturer’s tolerances and is installed in accordance with design specifications.
3. The tests and inspections shall determine suitability for startup and energization.
4. The following equipment shall be tested and calibrated:

- Electrical Power Conductors and Cables – Section 26 05 19
- Grounding and Bonding – Section 26 05 26
- Lighting Dimming and Lighting Controls – Section 26 09 33
- Network Lighting Control – Section 26 09 43
- Low Voltage Distribution Transformers – Section 26 22 13
- Low Voltage Switchgear – Section 26 23 00
- Distribution Switchboards – Section 26 24 13
- Panelboards – Section 26 24 16
- Diesel Engine Driven Generator Set - Section 26 32 13
- Automatic Transfer Switch – Section 26 36 23
- Static Uninterruptable Power Supply – Section 26 33 53
- Emergency Lighting Inverter – Section 26 53 10
- Paralleling Low Voltage Switchgear – Section 26 33 13

1.2 SUBMITTALS

A. Provide submittal per Contract General Conditions, Division 1, and Section 26 05 02.
B. Qualification of testing firm.
C. Submit five copies of certified test reports to Engineer for approval.
D. Five copies of blank forms for checklists, test reports, and other related forms for Engineer’s review and approval.

1.3 GENERAL REQUIREMENTS

A. The Contractor shall perform routine insulation resistance, continuity, and rotation tests for all distribution and utilization equipment prior to and in addition to any acceptance testing.
B. The Contractor shall test all lighting, low voltage relays and circuits to ensure proper operating conditions prior to acceptance testing.
C. The Contractor shall perform visual and mechanical inspections, verifying that the equipment nameplate information meets the intent of the drawings and specifications.
D. The Contractor shall be responsible for all final settings and adjustments on protective devices and tap changes, submitting settings to the Architect/Engineer for review.

E. Provide a complete short-circuit study, equipment interrupting/withstand evaluation, and a protective device coordination study for the electrical distribution system described herein. This study shall be submitted with electrical equipment submission and electrical room layouts.

F. The Contractor shall engage the services of a recognized corporate and financially independent testing firm for the purpose of performing inspections and tests as herein specified.

G. The firm shall provide all material, equipment, labor, and technical supervision to perform such tests and inspections.

H. It is the purpose of these tests to assure that all tested electrical equipment is operational and within industry and manufacturer’s tolerances and is installed in accordance with design specifications.

I. The tests and inspections shall determine suitability for energization. Equipment shall not be energized until accepted by the testing firm.

1.4 QUALIFICATIONS OF TESTING FIRM

A. The testing firm shall be a recognized corporate and financially independent testing organization which can function as an unbiased testing authority, professionally independent of the manufacturers, suppliers, and installers of equipment or systems evaluated by the testing firm.

B. The testing firm shall be regularly engaged in the testing of electrical equipment devices, installations, and systems.

C. The testing firm shall meet OSHA criteria for accreditation of testing laboratories, Title 29, Part 1907, or be a Full Member company of the InterNational Electrical Testing Association (NETA).

D. The lead, on-site, technical person shall be currently certified by the InterNational Electrical Testing Association (NETA) or National Institute for Certification in Engineering Technologies (NICET) in electrical power distribution system testing.

E. The testing firm shall utilize engineers and technicians who are regularly employed by the firm for testing and engineering services. All studies, tests, and reports shall be sealed by a registered electrical professional engineers with a current Colorado stamp.

F. The testing firm shall submit proof of the above qualifications with bid documents, when requested.

G. The terms used herewith, such as test agency, test contractor, testing laboratory, or contractor test company, shall be construed to mean the testing firm.

1.5 APPLICABLE CODES, STANDARDS, AND REFERENCES

A. All inspections and tests shall be in accordance with the following codes and standards except as provided otherwise herein:

1. National Electrical Manufacturer’s Association - NEMA
3. Institute of Electrical and Electronic Engineers - IEEE
6. State and City of Boulder Colorado Codes and Ordinances
7. University of Colorado at Boulder Electrical Standards
8. Insulated Cable Engineers Association - ICEA
9. Association of Edison Illuminating Companies - AEIC
10. Occupational Safety and Health Administration - OSHA
11. National Fire Protection Association - NFPA
   a. ANSI/NFPA 70: National Electrical Code
   b. ANSI/NFPA 70B: Electrical Equipment Maintenance
   c. NFPA 70E: Electrical Safety Requirements for Employee Workplaces
   d. ANSI/NFPA 780: Lightning Protection Code

B. All inspections and tests shall utilize the following references:
1. Project design specifications.
2. Project design drawings.
3. Short-circuit and coordination study.
4. Manufacturer’s instruction manuals applicable to each particular apparatus.
5. Project list of equipment to be inspected and tested as stated above.

PART 2 - SHORT-CIRCUIT AND COORDINATION STUDY

2.1 SHORT-CIRCUIT STUDY

The electrical equipment manufacturer shall perform a short-circuit analysis of the specified electrical power distribution system. This analysis shall include:

A. Calculation of the maximum RMS symmetrical three-phase short-circuit current available at significant locations in the electrical system. The results shall represent the highest short-circuit currents to which the equipment might be subjected under the reported system conditions. The short-circuit currents shall be calculated with the aid of a digital computer. Appropriate motor short-circuit contribution shall be included in the calculation.

B. The study shall include all portions of the electrical distribution system from the normal and alternate sources of power throughout the low-voltage distribution system. Normal system operating method, alternate operation, and operations which could result in maximum fault conditions shall be thoroughly covered in the study.

C. The study shall be calculated from the utility meter to the unit substation to the lowest overcurrent device or equipment on the electrical distribution system. The utility conductors shall not be used for calculations.

D. An evaluation of the adequacy of the short-circuit ratings of the electrical equipment supplied by that manufacturer.

E. Provide five copies of the short-circuit analysis for the engineer’s approval.

F. A computer printout of input data, a computer printout of calculated results and an explanation of how to interpret the printouts.

G. A one-line diagram identifying all bus locations and the maximum available short-circuit current at each bus.
H. A bus-to-bus listing of the maximum available short-circuit current expressed in RMS symmetrical amperes and the X/R ratio of the fault current.

I. A table of equipment short-circuit ratings versus calculated short-circuit current values.

J. An analysis of the results in which any inadequacies shall be called to the attention of the Engineer and recommendations made for improvements. These recommendations shall be incorporated by the electrical equipment manufacturer to the electrical equipment at no cost to the Owner. Where approved by the Engineer.

2.2 PROTECTIVE DEVICE COORDINATION STUDY

The electrical equipment manufacturer shall perform a protective device time-current coordination analysis of the entire electrical power distribution system. This analysis shall include:

A. A determination of settings or ratings for the over-current protective devices supplied. Where necessary, an appropriate compromise shall be made between system protection and service continuity with system protection and service continuity considered to be of equal importance. The time-current coordination analysis shall be performed with the aid of a digital computer.

B. An evaluation to the degree of system protection and service continuity possible with overcurrent devices supplied.

C. Provide five copies of the protective device time-current coordination analysis for the Engineer's approval.

D. Log-Log plots of time-current characteristic curves.

E. A tabulation of the suggested settings of the adjustable overcurrent protective devices supplied.

F. The key or limiting overcurrent device characteristics, load characteristics, and protection requirements affecting the setting or ratings of the overcurrent protective devices supplied.

G. The degree of service continuity and system protection achieved with the overcurrent protective devices supplied.

H. An analysis of the results in which any inadequacies shall be called to the attention of the Engineer and recommendations made for improvements.

2.3 ARC FLASH HAZARD ANALYSIS

A. Provide with the coordination and short circuit studies an Arc Flash study and device by device listing of PPE requirements and ratings as required by the NEC and NFPA 70E. All equipment shall have appropriate labeling installed in the field by the electrical contractor as determined by the study.

B. The flash protection boundary and the incident energy shall be calculated at all significant locations in the electrical distribution system (switchgear, switchboards, panelboards, busway, etc.) where work could be performed on energized parts.
PART 3 - INSPECTION AND TEST PROCEDURES

3.1 PROCEDURE

A. Testing firm to provide and comply with the following:

1. Acceptance test procedures for each individual equipment listed in Part 1 of this section for Engineer review and approval prior to any test and after thorough evaluation of the system. Testing shall conform to the latest version of InterNational Electrical Testing Association (NETA) specifications and standards for electrical power distribution equipment and systems and manufacturer’s instructions.
2. Refer to each individual specification section for testing requirements and comply.
3. Inspect installed equipment, record results and report any discrepancy and deficiency with contract documents and governing codes prior to testing. All results shall be submitted to the Engineer for approval.

3.2 FACTORY TESTING

A. Refer to the various Division 26 and 28 Specification sections for requirements for factory testing of equipment and devices.

3.3 FIELD TESTING

A. The entire electrical installation shall be inspected by the manufacturer and tested by the Electrical Contractor to ensure safety to building occupants and operating personnel, conformity to Code authorities and Contract Documents, including the General Conditions for design services and construction procedures.

B. Recognized safety procedures and techniques shall be used during energizing and de-energizing of all equipment to ensure employee safety and protect the work.

C. During the progress of the Work and upon completion, tests shall be made as specified herein and as required by authorities having jurisdiction including inspectors, Owner, Owner's insurance agency, Architect or Engineer. Tests shall be witnessed by the Electrical Contractor as part of the Work of this Division and shall include the services of qualified personnel as well as all equipment, apparatus, and services required. Each wiring system with devices connected must test free from short circuits and from grounds and must have an insulation resistance between conductors and ground, based on maximum load, not less than the requirements of the latest edition of the National Electrical Code and relevant industry standards such as NETA, IEEE, ANSI, etc.

D. The Electrical Subcontractor shall submit in writing proposed test procedures, recording forms, list of personnel and qualifications and test equipment for the Engineer's, Owner's, and CA's review.

1. Procedures shall include operation of entire electrical power system including:
   a. Voltage and current readings for each feeder and motor circuit under maximum operating conditions. Readings shall be submitted to the Engineer for review. Readings questioned shall be repeated for confirmation.
   b. Operation of lighting circuits with associated switching and controls.
   c. Running of motors with demonstration of controls and interlocks.
   d. Operation of transformers with voltage check while loaded to assure proper transformer tap settings.
   e. Operation of electrical equipment and appliances whether provided under this Division or not.
f. Ground fault protection system testing and calibration after construction is completed and prior to final acceptance.
g. Demonstration and operating test of the entire Fire Alarm and Mass Notification System as required by owner and AHJ.
h. Load banks, cables and connections for all heat runs shall be provided for all of the following tests, as part of this Contract.

3.4 EQUIPMENT TESTING

A. Service Switchgear and Distribution Switchboards

1. Service switchboards shall be megger tested.
2. Service switches shall be operated to confirm proper mechanical operation.
3. Test the accuracy of all meters with hand-held True RMS reading multimeters.
4. Ground fault trip/sensing systems shall be tested to verify their settings and proper activation. Polarity verification of the interconnection of the ground sensor circuits shall be performed.
5. Automatic throw-over on double ended switchgear.

B. Distribution Switchboards

1. Distribution switchboards shall be megger tested.
2. Distribution switches shall be operated to confirm proper mechanical operation.

C. Cable

1. Cables shall be megger tested. Individual cable shall be megger tested on an individual basis.
2. Grouping of phase conductors for a group measurement shall not be permitted.
3. Each conductor shall have its insulation resistance tested after the installation is completed and all splices, taps and connections are made prior to final connection to source or load.
4. Insulation resistance of conductors which are to operate at 600 volts or less shall be tested by using Biddle (or approved equal) Megger with an output of not less than 1000 volts d.c. Conductors shall be tested between phase conductors, between each phase conductor and neutral and ground, and between neutral and ground. Reading shall be observed after 15 seconds of operation of the Megger. Insulation resistance of conductors rated at 600 volts shall be not less than one (1) mega-ohm. (1,000,000 ohms), or the latest NEMA (IPCEA) Standard requirement for the conductor type or governing Code, whichever is more stringent.
5. Conductors that do not exceed insulation resistance values listed above shall be completely removed (source to load) and replaced and test repeated. The Contractor shall furnish all instruments and personnel required for tests.
6. For all conductors size No. 3/0 and larger, the Contractor shall tabulate readings observed and shall forward four copies of test readings to the Engineer for review. These test reports shall identify each conductor tested, date and time of test, weather conditions, temperature, and relative humidity. Each test shall be signed by party making the test. Any conductor or splice which is found defective shall be promptly removed and replaced, and additional tests shall be performed.
7. The above testing and report requirements shall apply to all No. 3/0 and larger conductors. Conductors No. 2/0 and smaller, branch circuits, control circuits, and signal circuits shall be checked in accordance with the NEC (National Electrical Code) Articles 110-7 and 250. If values are less than the minimum values noted in the Code, the feeder conductors shall be removed and replaced with conductors of identical size.
8. All feeders which can be paralleled shall be tested for proper phasing using hot phasing or other approved techniques.
D. Busway
   1. The busway system shall be infrared scanned. The entire busway system shall be scanned at full load from end to end. Provisions to provide load connections for testing shall be accounted for during installation to enable the full load test following the complete installation.

E. Transformers
   1. 50 percent load shall be provided on all transformers to confirm the secondary voltage. Secondary taps shall be adjusted as required to provide a minimum of 120/208 volts.
   2. Phase rotation shall be demonstrated as part of the operational checkout at the site.

F. Panelboards
   1. Following the installation of branch circuitry, phase currents shall be verified to ensure the balance of loads. Branch circuitry shall be reconnected to achieve a maximum imbalance of 10%.

G. Receptacles
   1. Receptacles shall be tested for polarity.

H. Light Switches Dimmers
   1. Light switches and wall mounted dimmers shall be tested for full dimming operation.

I. Egress Lighting
   1. All normal light fixtures shall be de-energized and all emergency egress lighting shall be verified.
   2. Emergency lighting inverter shall have a full operational test performed.

J. Lighting Control System
   1. Lighting relay panels shall have automatic and manual operational tests performed to verify all exterior lighting. Verify override switches are operational when included.
   2. Simulate programming times (i.e., "On", "Off") shall be input by the Contractor for the test, and following the completion of the test, the actual "on/off" times as required by the Owner shall be input into the system.

K. Dimming Systems
   1. Dimming systems shall have automatic and manual operational tests performed following the completion of the installation of the dimming systems and their associated remote controls.
   2. Initial dimming settings shall be input by the Contractor for the test based on the requirements of the Owner.

L. TVSS
   1. Verify the proper operation of all TVSS devices using the manufacturer's approved diagnostic test kit. Verify 0.5 ohms maximum ground continuity to all units.
M. Heat Tracing Cable
   1. Heating cable shall be megger tested. Megger tests shall be preformed at two periods
during installation; while the cable is still on the reel prior to installation and at the
completion of the installation.
   2. Megger testing shall include a 2500 VDC megohmeter between wires and the grounding
braid with a minimum reading of 20 megaohms.

N. Emergency Generators
   1. Each emergency generator shall be tested under load as required per specification
section 26.32.13.
   2. Both generators shall be paralleled and tested under load for minimum of four (4) hours
under full load utilizing the permanently installed load bank.
   3. At the completion of load bank test, simulate full power outage and test shunt trip of load
bank feeder breaker. Verify emergency system immediately picks up building load.

3.5 SYSTEM FUNCTION TESTS

A. General:
   1. Perform system function tests upon completion of equipment component tests as define
in this specification. It is the purpose of system function tests to prove the proper
interaction with several independent systems is operating in unison as a single and
complete system. The following systems shall be tested and provide with proper
documentation.

B. EPO Systems
   1. The EPO systems for each of the server room and the boiler room shall be tested for
proper operation. The EPO systems which are provided with a test selector switch setting
shall have this mode tested in addition to the actual actuation of all external system
shutdowns.

C. UPS System
   1. All system equipment being furnished as part of the UPS contract shall be tested at the
factory and at the site in accordance with the test procedures as detailed in specification
section 26.33.53.

D. Emergency Power System
   1. All system equipment being furnished as part of the emergency power system shall be
tested in accordance with this section.
   2. Test the operation of the standby power system with voltage check while the system is
fully loaded to assure proper operation of the electric generating system, paralleling
switchgear, transfer switches, low voltage switchgear motorized breaker sequence,
interface with BAS etc. Operation of the system shall simulate standby power conditions,
that is, loss of main electrical power to the building. Test shall verify main breakers open,
generator feeder breaker and tie breaker closes. The required feeder breakers open and
close as specified. Auxiliary signal is provide and received to the BAS and associated
mechanical equipment is de-energized as required. Test period shall be four (4)
continuous hours of trouble free operation. Test shall include a demonstration of the
safety shutdown devices. The Electrical Subcontractor shall furnish all fuel required for
testing and re-filling of tanks post testing. See Section 26.05.02 titled "GENERAL
E. Grounding System

1. The grounding systems shall be tested for stray currents and ground shorts at the completion of the installation.
2. Ground testing shall consist of opening all main disconnects for the system being tested and disconnecting the system neutral from the service entrance or step-down transformer neutral connection. D.C. ohmmeter shall measure resistance across the system neutral and equipment ground.
3. Reading in excess of 100 ohms shall indicate that the system neutral and equipment ground are properly isolated.
4. Ohmmeter reading less than 100 ohms shall indicate that the system contains ground shorts (stray currents) at some point along the system neutral.

F. Fire Alarm System

1. A complete operational test of the fire alarm system shall be performed.
2. Reference specification section 28 31 00 for additional requirements.

3.6 DEFICIENCIES

A. All deficiencies reported by testing firm to be corrected by Contractor and Acceptance Test to be re-done accordingly.

END OF SECTION
## SECTION 26 05 05
### MANUFACTURERS

### PART 1 - GENERAL

#### 1.1 DESCRIPTION

A. The following lists of manufacturers are for the specifications as identified.

B. All submittals and documentation shall be in accordance with the project General Requirements, Division 1.

### PART 2 - PRODUCTS

#### 2.1 MANUFACTURERS

A. Subject to compliance with requirements, manufacturers offering products which may be incorporated in the work are listed herein. All manufacturers not listed shall be pre-approved prior to bid in order to be considered. Refer to Division 1 for pre-approval format.

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General Electric Company  
Siemens (I-T-E-)  
Square D Company |
| - Circuit and Motor Disconnects | | |
| Connections | 26 28 16 | Appleton Electric Co.  
Burndy Corp.  
Ideal Industries, Inc.  
Thomas and Betts Corp. |
| Fuses (See Note) | 26 28 13 | Bussman (Basis of Design)  
Ferraz Shawmut  
Littlefuse |
| Diesel Engine Driven Generator Sets | 26 32 13 | Caterpillar Co.  
Waukesha  
Onan Corp. |
| Automatic Transfer Switches | 26 36 23 | Automatic Switch Company  
Caterpillar Co.  
Onan Corp.  
Russ Electric, Inc.  
GE Zenith |
| Transient Voltage Surge Suppression | 26 43 13 | Refer to Section |
| Lighting Fixtures | 26 51 13 | Refer to Drawings |
| Pole and Standards | 26 56 13 | Millerbernd Mfg. Co.  
Union Metal Mfg. Co.  
Valmont Industries, Inc. |
| - Metal Poles | 26 56 13 | A.B. Chance Co.  
Dixie Electrical Mfg. Co.  
Standley G. Flagg and Co., Inc.  
Hercules, Inc.  
Joslyn Mfg. and Supply Co.  
Lithonia Lighting Div.  
McGraw-Edison Co.  
Preform Line Products Co.  
Reliable Electric Co.  
Utilities Service Co. |
| - Pole Hardware | 26 56 13 | |
| Addressable Fire Alarm System | 28 31 00 | Simplex |
| Lightning Protection | 26 41 13 | National Lightning Protection  
Robbins Lightning, Inc.  
Triple C |

NOTE: Contractor shall submit fuse coordination for the entire electrical distribution if alternate manufacturer is used.

PART 3 - EXECUTION - Not Used.
SECTION 26 05 06
BASIC MATERIAL AND METHODS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
A. This Section supplements Division 1, General Requirements.

1.2 DESCRIPTION OF WORK
A. Work included in this section consists of conduits, wires and other miscellaneous materials not specifically mentioned in other sections of Division 26, 27 and 28 but necessary or required for equipment or system operation or function, and the labor to install them.

1.3 SUBMITTALS
A. Materials list with manufacturer, style, series or model identified.
B. Manufacturer’s descriptive literature and/or sample if requested by the Architect/Engineer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS: Refer to Section 26 05 05.

2.2 CONDUIT RACEWAYS: Refer to Section 26 05 33.

2.3 ELECTRICAL POWER CONDUCTORS AND CABLES: Refer to Section 26 05 19.

2.4 WIRING DEVICES: Refer to Section 26 27 26.

2.5 OUTLET BOXES, JUNCTION AND PULL BOXES
A. Outlet Boxes: Hot-dipped galvanized or sherardized of required size, 4” square minimum, for flush mounted devices and lighting fixtures. Cast-type FD with gasketed covers for surface-mounted devices.
B. Junction and Pull Boxes: Use outlet boxes as junction boxes wherever possible. Larger junction and pull boxes shall be fabricated from sheet steel, sized according to code, with screw-on covers, galvanized where required for outdoor exposure.
C. All exterior boxes shall be cast, gasketed, weatherproof type with cast covers.
D. Refer to Section 26 05 33 for additional requirements.

2.6 WIRE CONNECTORS
A. For wires that are #8 AWG and smaller: Insulated pressure type with live spring, rated 105°C, 600 volt, for building wiring and 1000 volt in signs or fixtures.
B. For wires that are #6 AWG and larger: Compression type with 3M #33 or equal tape insulation.
2.7 CONDUIT HANGERS
   A. Galvanized steel with special accessories for purpose and adequate to support load imposed. Support individual conduit 1-1/2-inch and larger and all multiple conduit runs with hangers. Clamp conduits individually to each support.
   B. Refer to Section 26 05 29 for additional requirements.

2.8 FUSES: Refer to Section 26 28 16.

2.9 ACCESS PANELS
   A. Electrical Contractor to provide access panels for electrical equipment which are required for accessibility by code.

2.10 TERMINAL CABINETS AND BACKBOARDS
   A. Fabricate from code gauge steel, size as indicated on drawings, with flush latch and concealed hinge. Where size is not indicated, minimum size shall be 20” wide x 24” high x 4” deep. Finish shall be ANSI 61 light gray baked enamel.
   B. Provide inside terminal cabinet, ¾” thick plywood backboard and terminal strips, one terminal point for each wire within the terminal cabinet.

2.11 CONDUIT SLEEVES
   A. Sleeves for Conduit Penetration: Hilti, Inc., model CP 682. Refer to Division 7 “Firestopping” for additional requirements.

2.12 EQUIPMENT MOUNTING AND SUPPORT HARDWARE
   A. Steel channels, bolts and washers, used for mounting or support of electrical equipment shall be galvanized typed. Where installed in corrosive atmosphere, stainless steel type hardware shall be used.
   B. Refer to Section 26 05 29 for additional requirements.

PART 3 - EXECUTION

3.1 GENERAL
   A. Provide complete raceway systems for all conductors including control wiring and low voltage wiring unless otherwise noted.
   B. Electrical system layouts indicated on drawings are generally diagrammatic, but shall be followed as closely as actual construction and work of other trades will permit. Govern exact routing of raceways and locations of outlets by structure and equipment served. Take all dimensions from architectural drawings.
   C. All home runs to panelboards are indicated as starting from the outlet nearest to the panel and continuing in the general direction of that panel. Continue such circuits to panel as though routes were completely indicated.
D. Avoid cutting and boring holes through structure or structural members wherever possible. Obtain prior approval of the Architect, and conform to all structural requirements when cutting or boring structure.

E. Furnish and install all necessary hardware, hangers, blocking, brackets, bracing, runners, etc., required for equipment specified under this Section.

F. Furnish and install all raceways from elevator machine room to fire command center for elevator status.

3.2 RACEWAYS: Refer to Section 26 05 33.

3.3 OUTLETS

A. Exact location of outlets and equipment shall be governed by structural conditions and obstructions or other equipment items. When necessary, relocate outlets so that when fixtures or equipment are installed, they will be symmetrically located according to room layout and will not interfere with other work or equipment. Verify final location of all outlets, panels, equipment, etc., with the Architect/Engineer.

B. Provide zinc-coated or cadmium-plated sheet steel outlet boxes not less than 4” octagonal or square, unless otherwise noted. Equip fixture outlet boxes with 3/8” no-bolt fixture studs. Where fixtures are mounted on or in an accessible type ceiling, provide a junction box and extend flexible conduit to each fixture. Outlet boxes in finished ceilings or walls shall be fitted with appropriate covers, set to come flush with the finished surface. Where more than one switch or device is located on one point, use gang boxes and covers unless otherwise indicated. Sectional switch boxes or utility boxes will not be permitted. Provide tile box or a 4” square box with tile ring in masonry walls which will not be plastered or furred, or where “dry-wall” type materials are applied. Through the wall type boxes are not permitted. Install minimum 12” lateral separation for back to back boxes.

C. Surface-mounted devices are to be mounted in cast type boxes with gasketed covers: (Crouse-Hinds condulets or equal).

D. Dimensions unless shown on drawings are given below and are from finished floor to center line of outlets unless noted otherwise. Adjust heights of outlets in masonry walls to correspond with consistent brick or block course. Outlets in block walls shall be installed in core of block.

- Wall Switches: 4’-0” (to top of switch)
- Convenience outlets: 1’-6” (to bottom of outlet)
- Hallways: 1’-6” (to bottom of outlet)
- Workroom wall outlet: 4’-4” (field verify height of backsplash)
- Panelboards wall-mounted: 6’-6” (to top of trim)
- Wall phone outlet: 4’-0” (verify with technology drawings)
- Telephone outlets: 1’-6” (verify with technology drawings)
- Fire alarm horns, speakers: ceiling or wall
- Fire alarm pull stations: 4’-0” (to top of device)
- Fire alarm strobes: 6’-8” or 6” below ceiling (whichever is lower)
- Television outlets: Refer to Technology or architectural drawing.

Confirm final location and heights of all outlets, wall switches, and television outlets with architectural and technology drawings and furniture plans prior to installation.
E. Outlets except over counters, benches, special equipment, baseboards, fin tube radiators, etc., or at wainscotting, shall be at a height to prevent interference to service equipment, or as noted on drawings.

F. Refer to Section 26 05 34 for additional requirements.

3.4 JUNCTION PULL BOXES

A. Construct junction or pull boxes not over 150 cubic inches in size shall be standard outlet boxes, and those over 150 cubic inches shall be constructed the same as “Cabinets,” with screw covers of same gauge metal. Removal covers must be accessible at all times.

B. Provide a standard access panel having a hinged metal door neatly fitted into a flush metal trim, where a junction box or equipment is located above non-accessible ceilings or behind finished walls. Coordinate location and type with the Architect.

END OF SECTION
PART 1 – GENERAL

1.1 WORK INCLUDED

A. The contractor shall summarize and document adherence with the requirements of the specifications for project closeout including:

1. Copies of all warranties
2. Operation & Maintenance Manuals
3. Required tests
4. Certifications
5. Record drawings
6. Permit requirements

B. The contractor shall compile a closeout manual which shall include:

1. A list of all required tests and a place for signoff of date completed.
2. A list of all submittals with dates of acceptance by the engineer.
3. A schedule indicating dates for beginning testing and startup of equipment and dates of tests to be witnessed by the engineer, or designated representative, as required by the specifications.
4. Test procedures to be used for life safety systems.
5. Project close out check list.

C. The final closeout manual shall include the following:

1. Test reports as required by the specifications with signoff by the appropriate individual (engineer, architect, building official, etc.).
2. Documentation indicating all equipment is operating properly and is fully accessible for maintenance.
3. Copies of all warranties.

D. This section only includes the requirements for documentation of the contract documents, by the contractor, for project completion. This section does not in any way decrease the scope of any of the drawings or specifications.

1.2 SUBMITTALS

A. Within 90 days after notice to proceed submit a preliminary closeout manual with the following:

1. A list of all required tests. Refer to specification section 26 05 03 – Testing.
2. Preliminary schedule showing major milestones for completion of the electrical and technology systems.

B. Within 30 days of the first major milestone submit the completed closeout manual as described in Part 1.

C. Within 2 weeks of substantial completion submit a completed “Project Closeout Check List”, and the Final Closeout Manual.

D. Listed below is a checklist for use by the contractor. This list is not all inclusive for this project.
Project Close-Out Summary - Electrical

☐ The following tests have been completed. Submit test report for record.
  ☐ Feeder Testing and Reporting (Megger Result)
  ☐ Transformers Testing and Reporting
  ☐ Grounding System Testing and Reporting
  ☐ Generator Testing and Reporting
  ☐ Main Switchgear Infrared Scans, Testing and Reporting

☐ All main components of the electrical system cleaned and vacuumed. This includes unit substations, switchboards, distribution boards, panel boards, etc. Provide M-E Engineers with schedule when this is going to occur and a letter stating it has been completed.

☐ The contractor shall schedule a walk through with the engineer to inspect all main feeder sizes. Covers for panel boards and distribution boards should be removed by the contractor for visual inspection of feeder sizes.

☐ Fixtures re-lamped per specifications.

☐ The fire alarm system manufacturer shall provide the Owner/Architect with a “Letter of Certification” indicating the system is fully functional and meets all manufacturers requirements as well as code and design requirements. Fire department must sign off the system.

☐ Provide spare fuses and fuse cabinets (1) in each switch gear room) per specifications.

☐ Mimic Bus installed on Unit substations per specification.

☐ Panelboard directories completed.

☐ Record drawings submitted.

☐ All lighting control systems complete with controls fully operational for visual inspections.

☐ The lightning protection system manufacturer shall provide the Owner/Architect with a “Letter of Certification” indicating the system meets all manufacturers requirements as well as code and design requirements.
PART 2 – PRODUCTS (Not Used)

PART 3 – EXECUTION

3.1 EQUIPMENT STARTUP AND TESTING

A. Prior to completion and punchlist by the engineer, the contractor shall startup and test each piece of equipment as required by the specifications. The contractor shall provide documentation of all required tests with signoff of by the appropriate individual (engineer, architect, and building official).

3.2 LIFE SAFETY SYSTEMS

A. All life safety systems shall be fully and successfully tested by the contractor before being witnessed by the engineer or building official.

B. The contractor shall provide a detailed test procedure, with instrumentation to be used, for approval by the engineer and building official prior to any testing.

C. Once tested by the contractor and fully operation the systems shall be demonstrated to the engineer. Once accepted by the engineer the system shall be demonstrated to the building and fire officials.

3.3 COORDINATION WITH OTHERS

A. The Division 26 contractor shall coordinate his requirements with the general contractor to ensure the other building systems are completed to the point that they will not adversely affect the operation of the Division 26, 27 and 28 systems.

3.4 PUNCH LISTS

A. The contractor shall submit in writing that the project is ready for final review by the engineer.

B. Once the project is ready for final review the engineer will create a punch list of any corrections or deficiencies.

C. The contractor shall complete all punch list items and provide a letter to the architect after completion stating all items have been completed or reasons why they were not completed.

D. Upon receipt of this letter the engineer will verify that the punch list has been satisfactorily completed.

END OF SECTION
PART 1 - GENERAL

1.1 DESCRIPTION

A. The purpose of this section is to specify Division 26 responsibilities in the commissioning process.

This section assumes that a Commissioning Authority (CA) is part of the project reporting directly to the Owner and is authorized to act on behalf of the Owner as called out herein. In any situation where a CA is not a part of the project, all responsibilities called to be by the CA will be performed by the Construction Manager reporting directly to the Owner.

This section assumes that a Construction Manager (CM) is reporting directly to the Owner and is authorized to act on behalf of the Owner as called out herein. In any situation where a CM is not a part of the project, all responsibilities called to be by the CM will be performed by the General Contractor reporting directly to the Owner.

B. Commissioning (Cx) requires the participation of Division 26 to ensure that all systems are operating in a manner consistent with the Contract Documents. The specific commissioning requirements will be presented in a Commissioning Plan developed by the project’s Commissioning Authority (CA). Division 26 shall become familiar with all parts of the Commissioning Plan issued by the CA and shall execute all commissioning responsibilities assigned to them in the Contract Documents.

C. This Commissioning Plan deconstructs the commissioning procedure into a series of progressive tasks that must be competed in succession to properly commission the system under review. The five stages are defined as the FACTORY TESTING, VENDOR START-UP, PRE-FUNCTIONAL VERIFICATION, FUNCTIONAL VERIFICATION and SYSTEM PERFORMANCE STAGES and can be described as follows:

1. The first stage is the FACTORY TESTING stage and it defines all the items required for the functional testing of the equipment in a factory setting. The items completed during this period will lay the foundation for the vendor start-up and functional testing of the system and the equipment within. This stage will require the manufacturer to test all equipment functions and prepare a certified factory test report prior to shipping the equipment.

2. The second stage is the VENDOR START-UP stage and it defines all the items required to be inspected, tested and checked for the initial start-up of the equipment. The items completed during this period will lay the foundation for the functional and acceptance testing of the system and the equipment within. This stage is an integral part of the EQUIPMENT PRE-FUNCTIONAL stage. This stage will require the cooperation of the equipment manufacturer.

3. The third stage is the EQUIPMENT PRE-FUNCTIONAL stage and it defines all the items required for the installation and includes as one item, the initial start-up of the equipment. The items completed during this period will lay the foundation for the start-up and later acceptance of the system and the equipment within. This stage will require the cooperation of the commissioning agent, site personnel, and design engineer. During this stage the installing contractor and manufacturer will be required to complete the items of work on the pre-functional check list and related test forms. Through meetings with the CA, it will be determined which items on the check list are
required prior to start-up and which items can follow for completion of the check list. Upon completion, including factory testing, field start-up, all tests and visual inspections, the installing contractor and manufacturer shall submit the pre-functional check list and test forms to the CA for approval. Upon receipt of approval, the functional testing can be scheduled.

4. The fourth stage consists of the **EQUIPMENT FUNCTIONAL TEST** items. The series of tests performed during this stage determines the suitability of the installed components to be placed into service and for compliance with the design and operational intent of the equipment. This stage will require the collaboration of the installing contractor with the manufacturer’s representative to help assure an operational system is ready for final acceptance. During the functional testing the equipment will be subjected to all possible operating modes. The unit will then be tested to confirm that all alarm and BMS functions operate as designed. Upon completion of the alarm testing the manufacturer will prove all settings to the CA by either showing alarm setpoints on the control panel or simulating alarm conditions and failure modes.

5. The final stage is the **SYSTEM PERFORMANCE VERIFICATION TEST** phase, which will integrate the equipment with the other system components for final evaluation by the CA. This stage will require the installing contractor and manufacturer’s representative to operate the installed equipment for the owner’s representative, CA and engineer of record’s final approval.

**1.2 RESPONSIBILITIES**

A. **Electrical Contractors.** The commissioning responsibilities applicable to each of the Electrical contractors of Division 26 are as follows:

1. Provide startup for all electrical equipment.
2. Assist and cooperate with the CA by:
3. List and clearly identify on the as-built drawings the locations of all electrical components and devices including measure and verification devices.
4. Prepare a preliminary schedule for Division 26 testing, cleaning, and equipment start-up and completion for use by the CA. Update the schedule as appropriate.
5. Notify the CM or CA depending on protocol, when testing, cleaning, and equipment start-up and completion for use of each piece of equipment will occur. Be responsible to notify the CM, ahead of time, when commissioning activities not yet performed or not yet scheduled will delay construction. Be proactive in seeing that commissioning processes are executed and that the CA and CM both have the scheduling information needed to efficiently execute the commissioning process.

6. Provide the following:
   a. Putting all equipment and systems into operation and continuing the operation during each working day of commissioning, as required.
   b. Including cost of fuses and consumable devices that may be required by CA.

**Construction and Acceptance Phases**

1. Include and itemize the cost of commissioning in the contract price.
2. In each purchase order or subcontract written, include requirements for submittal data, commissioning documentation, O&M data and training.
3. Attend commissioning scoping meetings and other meetings necessary to facilitate the Cx process.
4. Contractors shall provide the CA with normal cut sheets and shop drawing submittals of commissioned equipment.
5. Provide additional requested documentation, prior to normal O&M manual submittals, to the CA for development of start-up, pre-functional and functional testing procedures.
   a. Typically this will include detailed manufacturer installation and start-up, operating, troubleshooting and maintenance procedures, full details of any owner-contracted
tests, performances curves, full factory testing reports, if any, and full warranty information, including all responsibilities of the Owner to keep the warranty in force clearly identified. In addition, the installation, start-up and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted to the Commissioning Authority.

b. The Commissioning Authority may request further documentation necessary for the commissioning process.

c. This data request may be made prior to normal submittals.

6. Provide a copy of the O&M manuals and submittals of commissioned equipment, through normal channels, to the CA for review and approval.

7. Contractors shall assist (along with the design engineers) in clarifying the operation and control of commissioned equipment in areas where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.

8. Provide limited assistance to the CA in preparing the specific pre-functional and functional performance test procedures as outlined in the Commissioning Plan. Subs shall review test procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests.

9. Develop a full start-up and initial checkout plan using manufacturer’s start-up procedures and the pre-functional checklists from the CA for all commissioned equipment. Submit to CA for review and approval prior to startup.

10. During the startup and initial checkout process, execute the Electrical-related portions of the pre-functional checklists for all commissioned equipment.

11. Perform and clearly document all completed startup and system operational checkout procedures, providing a copy to the CA.

12. Address current A/E punch list items before functional testing.

13. Provide skilled technicians to execute starting of equipment and to execute the functional performance tests. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem-solving.

14. Provide skilled technicians to perform functional performance testing under the direction of the CA for specified equipment outlined in the Commissioning Plan. Assist the CA in interpreting the monitoring data, as necessary.

15. Correct deficiencies (differences between specified and observed performance) as interpreted by the CA, CM and A/E and retest the equipment.

16. Prepare O&M manuals according to the Contract Documents, including clarifying and updating the original sequences of operation as-as-built conditions.

17. During construction, maintain as-built red-line drawings for all drawings and final CAD as-builds for contractor-generated coordination drawings. Update after completion of commissioning (excluding deferred testing).

18. Provide training of the Owner’s operating staff using expert qualified personnel, as specified.

19. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.

20. Provide standby and assistance for specific testing requiring the coordination of multiple trades and where this contractor’s equipment and systems are a part of the test or must be functioning to allow for complete performance and testing verification. This shall include but not be limited to the “Pull the Plug” test, emergency generator testing, etc.

21. Coordinate with other Division 26 contractors (additional subs and other trades) on the project as required and directed by the CM and CA.

22. Attend Commissioning coordination meetings and provided assistance and cooperate in the preparation of a commissioning schedule with the CM and CA.

23. Commissioning Tasks shall be performed by the same personnel who were involved in the installation and are familiar with the equipment.

24. Provide training plan submittal and obtain approval prior to training.
**Warranty Period**
1. Execute seasonal or deferred functional performance testing, witnessed by the CA, according to the specifications.
2. Correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for applicable issues identified in any seasonal testing.

### 1.3 RELATED WORK

A. Refer to the Commissioning Plan for a listing of all commissioning requirements.

B. Refer to the Commissioning Plan for systems to be commissioned and pre-functional and functional testing requirements.

C. The Subcontractor and Vendors will be required to assist in the testing and verification of certain systems to assure the proper performance of their equipment. The equipment will be functional during the Emergency Systems, UPS and “Pull the Plug” tests to simulate complete power failure. The Subcontractor and Vendor must perform the test in advance and provide verification of the equipment performance. Refer to the Draft Commissioning Plan for additional information and requirements.

D. The project will undergo a commissioning and measurement and verification process. The Subcontractor and Vendors shall be required to sign-off on that all components and devices have been installed as per the manufacturer’s recommendations and been properly calibrated prior to the CA commencing this process. Refer to the Draft Commissioning Plan for additional information and requirements.

### PART 2 - PRODUCTS

#### 2.1 TEST EQUIPMENT

A. All standard testing equipment required to perform startup and initial checkout and required functional performance testing shall be provided by the Division contractor for the equipment being tested. For example, the Electrical contractor of Division 26 shall ultimately be responsible for all standard testing equipment for the Electrical system and controls system in Division 26, except for equipment specific to and used by TAB in their commissioning responsibilities. The Contractor shall review all test requirements and have on hand any devices needed so as not delay the process in the field. An example would be amperage readings shall require the Contractor to have an amp probe immediately on hand. Two-way radios shall be provided by the Division 26 Contractor.

B. Special equipment, tools and instruments (only available from vendor, specific to a piece of equipment) required for testing equipment, according to these Contract Documents shall be included in the base bid price of the Contractor and left on site, except for stand-alone datalogging equipment that may be used by the CA.

C. Datalogging equipment and software required to test equipment will be provided by the BMS Contractor, and shall become the property of the Owner.

D. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5°F and a resolution of + or - 0.1°F. Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year. All equipment
shall be calibrated according to the manufacturer’s recommended intervals and when dropped or damaged. Calibration tags shall be affixed or certificates readily available.

E. Refer to the Commissioning Plan for details regarding equipment that may be required to simulate required test conditions.

PART 3 – EXECUTION

3.1 GENERAL REQUIREMENTS:

The general process of the Execution of the Commissioning Process will require the completion of the following steps / functions / procedures:

A. The Vendor / Manufacturer will be required to perform factory testing as described in the specific equipment documentation / specifications and provide certified factory test reports on certain pieces of equipment. Not every section of the specification will require a factory test. Where factory testing is called for, each piece of equipment must be tested unless noted otherwise.

B. The contractor with the assistance of the Vendor / Manufacturer will be required to perform a field startup test (manufacturer’s startup) of specific pieces of equipment as described in the specific equipment documentation / specifications.

C. Upon completion of factory testing, submittal of factory test report(s) that is approved by the Engineer and completion of the manufacturer’s field startup test, the vendor can complete the pre-functional checks as identified in the Commissioning Plan.

D. The CA will meet with the Contractor to develop proper test procedures and observe each Contractor performing the initial test of one Pre-functional Check of a specific piece of equipment or testing process. Once one check is administered, the contractor / vendor will be responsible for completing the remainder of the similar checks under the supervision of the CM. The Contractor shall be responsible for completing the forms electronically and submitting them to the CA for review and approval.

E. Upon submission of pre-functional testing and approval of pre-functional testing forms by the CA, the vendor can then schedule the functional testing of the equipment that will be witnessed at a minimum by the CA and CM.

F. The CA will observe and administer each Functional Test of each piece of equipment and will document the results of the test.

G. Upon successful completion of the functional system test and sign-off from all parties involved the vendor can schedule any training sessions with site personnel that may be required.

H. If a Systems Integration test is required for a particular piece of equipment, the additional tests will be scheduled by the CA & CM.

See the Commissioning Plan for additional information.

3.2 SUBMITTALS

A. Division 26 shall provide submittal documentation relative to commissioning as required in this Section.
3.3 STARTUP

A. The electrical and controls contractors shall follow the start-up and initial checkout procedures listed in the Responsibilities list in this section and in the Commissioning Plan. Division 26 has start-up responsibility and is required to complete systems and sub-systems so they are fully functional, meeting the design objectives of the Contract Documents. The commissioning procedures and pre-functional and functional testing do not relieve or lessen this responsibility or shift that responsibility partially to the Commissioning Authority, CM or Owner.

B. Functional testing is intended to begin upon completion of a system. Functional testing may proceed prior to the completion of systems or sub-systems at the discretion of the CA and Owner. Beginning system testing before full completion, does not relieve the Contractor from fully completing the system, including all pre-functional checklists as soon as possible.

3.4 PRE-FUNCTIONAL AND FUNCTIONAL PERFORMANCE TESTS

A. Refer to the Commissioning Plan for a list of systems to be commissioned for a description of the process and for specific details on the required functional performance tests.

B. Pre-functional Checklist (PC) - a list of items to inspect and elementary component tests to conduct to verify proper installation of equipment, provided by the CA to the Sub. Pre-functional checklists are primarily static inspections and procedures to prepare the equipment or system for initial operation (e.g., belt tension, oil levels OK, labels affixed, gages in place, sensors calibrated, etc.). However, some pre-functional checklist items entail simple testing of the function of a component, a piece of equipment or system (such as measuring the voltage imbalance on a three phase pump motor of a chiller system). The word pre-functional refers to before functional testing. Pre-functional checklists augment and are combined with the manufacturer's start-up checklist. Even without a commissioning process, contractors typically perform some, if not many, of the pre-functional checklist items a commissioning authority will recommend. However, few contractors document in writing the execution of these checklist items. Therefore, for most equipment, the contractors execute the checklists on their own. The commissioning authority only requires that the procedures be documented in writing, and does not witness much of the pre-functional checklisting, except for larger or more critical pieces of equipment.

C. Functional Performance Test (FT) - test of the dynamic function and operation of equipment and systems using manual (direct observation) or monitoring methods. Functional testing is the dynamic testing of systems (rather than just components) under full operation. Systems are tested under various modes, such as during low cooling or heating loads, high loads, component failures, unoccupied, varying outside air temperatures, fire alarm, power failure, etc. The systems are run through all the control system’s sequences of operation and components are verified to be responding as the sequences state. The commissioning authority develops the functional test procedures in a sequential written form, coordinates, oversees and documents the actual testing, which is usually performed by the installing contractor or vendor. Functional Tests are performed after pre-functional checklists and startup are complete.

3.5 TESTING DOCUMENTATION, NON-CONFORMANCE AND APPROVALS

A. Documentation. The CA shall witness and document the results of all functional performance tests using the specific procedural forms developed for that purpose. Prior to testing, these forms are provided to the Subs for review. The Subs will include the filled out forms in the O&M manuals.
B. Non-Conformance.

1. The CA will record the results of the functional test on the procedure or test form. All deficiencies or non-conformance issues shall be noted and reported to the CM on a standard non-compliance form.

2. Corrections of minor deficiencies identified may be made during the tests at the discretion of the CA. In such cases the deficiency and resolution will be documented on the procedure form.

3. Every effort will be made to expedite the testing process and minimize unnecessary delays, while not compromising the integrity of the procedures. However, the CA will not be pressured into overlooking deficient work or loosening acceptance criteria to satisfy scheduling or cost issues, unless there is an overriding reason to do so at the request of the Owner.

4. As tests progress and a deficiency is identified, the CA discusses the issue with the executing contractor.
   a. When there is no dispute on the deficiency and the Sub accepts responsibility to correct it:
      1) The CA documents the deficiency and the Sub’s response and intentions and they go on to another test or sequence. After the day’s work, the CA submits the non-compliance reports to the CM for signature, if required. A copy is provided to the Sub and CA. The Sub corrects the deficiency, signs the statement of correction at the bottom of the non-compliance form certifying that the equipment is ready to be retested and sends it back to the CA.
      2) The CA reschedules the test and the test is repeated.
   b. If there is a dispute about a deficiency, regarding whether it is a deficiency or who is responsible:
      1) The deficiency shall be documented on the non-compliance form with the Sub’s response and a copy given to the CM and to the Sub representative assumed to be responsible.
      2) Resolutions are made at the lowest management level possible. Other parties are brought into the discussions as needed. Final interpretive authority is with the A/E. Final acceptance authority is with the Owner.
      3) The CA documents the resolution process.
      4) Once the interpretation and resolution have been decided, the appropriate party corrects the deficiency, signs the statement of correction on the non-compliance form and provides it to the CA. The CA reschedules the test and the test is repeated until satisfactory performance is achieved.

5. Cost of Retesting.
   a. The cost for the Sub to retest a pre-functional or functional test, if they are responsible for the deficiency, shall be theirs. If they are not responsible, any cost recovery for retesting costs shall be negotiated with the CM.
   b. For a deficiency identified, not related to any pre-functional checklist or start-up fault, the following shall apply: The CA and CM will direct the retesting of the equipment once at no “charge” to the Subcontractor for their time. However, the CA’s and CM’s time for a second retest will be charged to the Subcontractor.
   c. The time for the CA and CM to direct any retesting required because a specific pre-functional checklist or start-up test item, reported to have been successfully completed, but determined during functional testing to be faulty, will be backcharged to the Subcontractor for executing the faulty pre-functional test.
   d. Refer to the Commissioning Plan for requirements for testing and retesting identical equipment.

6. The Contractor shall respond in writing to the CA and CM at least as often as commissioning meetings are being scheduled concerning the status of each apparent outstanding discrepancy identified during commissioning. Discussion shall cover explanations of any disagreements and proposals for their resolution.
7. The CA retains the original non-conformance forms until the end of the project.
8. Any required retesting by any contractor shall not be considered a justified reason for a claim of delay or for a time extension by the prime contractor.

C. Failure Due to Manufacturer Defect. If 10%, or three, whichever is greater, of identical pieces (size alone does not constitute a difference) of equipment fail to perform to the Contract Documents (mechanically or substantively) due to manufacturing defect, not allowing it to meet its submitted performance spec, all identical units may be considered unacceptable by the CM. In such case, the Contractor shall provide the Owner with the following:

1. Within one week of notification from the CM, the Contractor or manufacturer’s representative shall begin examining all other identical units until a representative number of units, as determined by the Engineer, are examined sufficient to determine the extent and cause of the failure. The findings shall be recorded and provided to the CM within two weeks of the original notice.
2. Within two weeks of the original notification, the Contractor or manufacturer shall provide a signed and dated, written explanation of the problem, cause of failures, etc. and all proposed solutions which shall include full equipment submittals. The proposed solutions shall not significantly exceed the specification requirements of the original installation.
3. The CM will determine whether a replacement of all identical units or a repair is acceptable.
4. Two examples of the proposed solution will be installed by the Contractor and the CM will be allowed to test the installations for up to one week, upon which the CM will decide whether to accept the solution.
5. Upon acceptance, the Contractor and/or manufacturer shall replace or repair all identical items, at their expense and extend the warranty accordingly, if the original equipment warranty had begun. The replacement/repair work shall proceed with reasonable speed beginning within one week from when parts can be obtained.

D. Approval. The CA notes each satisfactorily demonstrated function on the test form. Formal approval of the functional test is made later after review by the CA and by the CM, if necessary. The CA recommends acceptance of each test to the CM using a standard form. The CM gives final approval on each test using the same form, providing a signed copy to the CA and the Contractor.

3.6 OPERATION AND MAINTENANCE (O&M) MANUALS

A. Contractors shall comply with the requirements of specification Section 26 05 02, “Basic Electrical Requirements” regarding O&M Manuals.

3.7 TRAINING OF OWNER PERSONNEL

A. Construction Manager - The CM shall be responsible for training coordination and scheduling and ultimately to ensure that training is completed. Refer to Section 26 05 02 for additional details.

B. Commissioning Authority - The CA shall be responsible for overseeing and approving the content and adequacy of the training of Owner personnel for commissioned equipment. Refer to Section 26 05 02 for additional details.

C. Electrical Contractor - The Electrical contractor shall perform training utilizing both classroom instruction and field demonstrations. Refer to Section 26 05 02 for additional details.
3.8 DEFERRED TESTING

A. Unforeseen Deferred Tests. If any check or test cannot be completed due to the building structure, required occupancy condition or other deficiency, execution of checklists and functional testing may be delayed upon approval of the PM. These tests will be conducted in the same manner as the seasonal tests as soon as possible. Services of necessary parties will be negotiated.

B. Seasonal Testing. During the warranty period, seasonal testing (tests delayed until weather conditions are closer to the system’s design) specified in Commissioning Plan shall be completed as part of this contract. The CA and CM shall coordinate this activity. Tests will be executed, documented and deficiencies corrected by the appropriate Subs, with facilities staff and the CA witnessing. Any final adjustments to the O&M manuals and as-builts due to the testing will be made.

3.9 WRITTEN WORK PRODUCTS

A. The commissioning process generates a number of written work products described in various parts of the Specifications. The Commissioning Plan shall list all the formal written work products, describes briefly their contents, who is responsible to create them, their due dates, who receives and approves them and the location of the specification to create them. In summary, the written products are:

<table>
<thead>
<tr>
<th>Product</th>
<th>Developed By</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Final commissioning plan</td>
<td>CA</td>
</tr>
<tr>
<td>2. Meeting minutes</td>
<td>CA</td>
</tr>
<tr>
<td>3. Commissioning schedules</td>
<td>CA with CM</td>
</tr>
<tr>
<td>4. Equipment documentation submittals</td>
<td>Subs</td>
</tr>
<tr>
<td>5. Sequence clarifications</td>
<td>Subs and A/E as needed</td>
</tr>
<tr>
<td>5. Prefunctional checklists</td>
<td>CA with Subs</td>
</tr>
<tr>
<td>6. Startup and initial checkout plan</td>
<td>Subs and CA (compilation of existing documents)</td>
</tr>
<tr>
<td>7. Startup and initial checkout forms</td>
<td>Subs</td>
</tr>
<tr>
<td>8. Final TAB report</td>
<td>TAB</td>
</tr>
<tr>
<td>9. Issues log (deficiencies)</td>
<td>CA and CM</td>
</tr>
<tr>
<td>10. Commissioning Progress Record</td>
<td>CA</td>
</tr>
<tr>
<td>11. Deficiency reports</td>
<td>CA and CM</td>
</tr>
<tr>
<td>12. Functional test forms</td>
<td>CA and Subs</td>
</tr>
<tr>
<td>13. Filled out functional tests</td>
<td>Subs and CA</td>
</tr>
<tr>
<td>14. O&amp;M manuals</td>
<td>Subs</td>
</tr>
<tr>
<td>15. Commissioning record book</td>
<td>CA</td>
</tr>
<tr>
<td>16. Overall training plan</td>
<td>CA and CM</td>
</tr>
<tr>
<td>17. Specific training agendas</td>
<td>Subs</td>
</tr>
<tr>
<td>18. Final commissioning report</td>
<td>CA</td>
</tr>
<tr>
<td>19. Misc. approvals</td>
<td>CA</td>
</tr>
</tbody>
</table>

END OF SECTION
SECTION 26 05 19
ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Requirement of the following Division 26 Sections apply to this section:
   1. Electrical Requirements

1.2 SUMMARY

A. This Section includes wires, cables, and connectors for power, lighting, signal, control and related systems rated 600 volts and less.

B. Related Sections: The following Sections contain requirements that relate to this section:
   1. Division 2 Section “Earthwork” for trenching and backfilling.
   2. Division 26 Section “Electrical Boxes and Fittings” for connectors for terminating cables in boxes and other electrical enclosures.

1.3 SUBMITTALS

A. Product Data for electrical wires, cables and connectors.

1.4 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with provisions of the following code:

B. NFPA 70 “National Electrical Code.”
   1. Conform to applicable codes and regulations regarding toxicity of combustion products of insulating materials.

C. UL Compliance: Provide components, which are listed and labeled by UL under the following standards.
   1. UL Std. 44 Rubber Insulated Wires and Cables
   2. UL Std. 83 Thermoplastic-Insulated Wires and Cables
   3. UL Std. 486A Wire Connectors and Soldering Lugs for Use with Copper Conductors
   4. UL Std. 854 Service Entrance Cable

D. NEMA/ICEA Compliance: Provide components which comply with the following standards:
   1. WC-5: Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
   2. WC-7: Cross Linked Thermosetting Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
E. IEEE Compliance: Provide components, which comply with the following standard.
   1. Std. 82: Test procedures for Impulse Voltage Tests on Insulated Conductors.

PART 2 - PRODUCTS

2.1 WIRES AND CABLES 600 VOLT COPPER CONDUCTORS

A. General: Provide suitable wire and cable for the temperature, conditions and location where
   installed. All wires and cables shall be new and delivered to the site in unbroken packages and
   reels.

B. All wires and cables shall be of the same manufacturer throughout the entire project.

C. Conductors: Provide solid conductors for power and lighting circuits #12 AWG and smaller.
   Provide stranded conductors for #10 AWG and larger.

D. Conductor Material: All wires and cables shall be copper, single conductor rated at 600 volts,
   which conform to or exceed ICEA specifications and the following:
   1. In sizes 1/0 AWG to 4/0: Cross-linked polyethylene insulation type XHHW-2 (75 - 90°C)
      or THWN.
   2. In sizes 250 KCMIL and larger: Type XHHW-2 (75°C) or THWN.
   3. In sizes 1 AWG and smaller: All conductors shall have heat/moisture resistant
      thermoplastic insulation type THWN (75°C) except as follows:
      a. Where conduit temperature will exceed 100°F, use type THHN (90°C).
      b. In 120 volt incandescent fixtures, type SF-2 or SFF-2 (150 - 200°C).
      c. In wireway of fluorescent lighting fixtures type THHN (90°C).

E. Grounding conductors: Shall be of the same type as its associated phase conductors.

F. All conductors shall be label with wire size, insulation rating, etc using an engraved process,
   computer scan on labels are not permitted.

G. Color Coding for phase identification in accordance with Table 1 in Part 3 herein.

H. Connectors for Conductors:
   1. Provide UL-listed factory-fabricated, solderless metal connectors of sizes, ampacity
      ratings, materials, types and classes for applications and for services indicated. Use
      connectors with temperature ratings equal to or greater than those of the wires upon
      which used.

I. Splices and Taps:
   1. No. 12 AWG and smaller - Connectors for solid conductors shall be solderless, screw-on,
      spring pressure cable type, 600 volt, 105°C with integral insulation and UL approved for
      aluminum and copper conductors. Connectors for stranded conductors shall be crimp-on
      type with integral insulating cover.
   2. No. 10 AWG and larger - Hydraulically applied crimping sleeve or tap connector sized for
      the conductors. Insulate the hydraulically applied connector with 90-degree, 600-volt
      insulating cover provided by the connector manufacturer. Insulator materials and
      installation shall be approved for the specific application, location, voltage, and
      temperature and shall not have an insulation value less than the conductors being joined.
J. Aluminum conductors are prohibited.

K. The use of modular wiring systems is prohibited.

PART 3 - EXECUTION

3.1 WIRING METHOD

A. Use the following wiring methods as indicated:

1. Install all wire in raceway. Power and control wiring shall be installed in separate raceways.

3.2 INSTALLATION OF WIRES AND CABLES

A. General: Install electrical cables, wires, and connectors in compliance with NEC.

B. Coordinate cable and wire installation with other Work.

C. Do not install more conductors in a raceway than indicated on the drawings. A maximum of three branch circuits are to be installed in any one conduit on a 3-phase, 4-wire system, unless specifically noted otherwise on the drawings. When more than three branch circuits are installed in a raceway, the conductor size shall be increased per code for derating. No two branch circuits of the same phase are to be installed in the same conduit, unless specifically noted otherwise on the drawings.

D. Minimum wire size shall be a No. 12 AWG except for control or signal circuits, which may be No. 14 AWG.

E. Unless otherwise indicated on drawings, all wiring for branch circuits shall be a minimum No. 12 AWG in 7/8” conduit, protected by 20 amperes circuit breakers. If distance from panel to first outlet is 75 feet or greater for 120 volt circuits, and 125 feet or greater for 277 volt circuits, No. 10 AWG shall be installed throughout the circuit, unless noted otherwise on the drawings.

F. Size of current carrying conductors, unless noted otherwise on drawings, shall be determined from Table 310-16 of the latest National Electric Code for the load served.

G. Pull conductors simultaneously where more than one is being installed in same raceway. Use UL listed pulling compound or lubricant, where necessary.

H. Use pulling means including: fish tape, cable, rope, and basket weave wire/cable grips which will not damage cables or raceways. Do not use rope hitches for pulling attachment to wire or cable.

I. Size of conduits, unless specifically shown, shall be determined from Appendix C of the latest National Electrical Code.

J. Keep conductor splice to minimum. All splices shall be made within junction boxes, wiring troughs and other enclosures as permitted by the National Electrical Code. Do not splice conductors in panelboards, safety switches, switchboards, motor control centers or motor control enclosures. Splices in conductors installed below grade will not be permitted, unless approved in writing by the Architect.

K. Install splice and tap connectors, which possess equivalent or better mechanical strength and insulation rather than conductors being spliced.
L. Use splice and tap connectors which are compatible with conductor material.

M. Provide adequate length of conductors within electrical enclosures and train the conductors to terminal points with no excess. Bundle multiple conductors, with conductors larger than No. 10 AWG cabled in individual circuits. Make terminations so there is no bare conductor at the terminal.

N. Tighten electrical connectors and terminals, including screws and bolts, in accordance with manufacturers’ published torque tightening values. Where manufacturers’ torque requirements are not indicated, tighten connectors and terminals to comply with tightening torque values specified in UL 486A and UL 486B.

O. Parallel feeders shall be installed so that all runs are of identical equal lengths.

P. Length of conductors at receptacles, junction switches at least 6” of free conductor shall be left at each outlet, junction and switches for splices or connection of fixtures or devices.

3.3 FIELD QUALITY CONTROL

A. Prior to energizing, check installed wires and cables with megohm meter to determine insulation resistance levels to assure requirements are fulfilled.

B. Prior to energizing, test wires and cables for electrical continuity and for short circuits.

C. Subsequent to wire and cable hook-ups, energize circuits and demonstrate proper functioning. Correct malfunctioning units, and retest to demonstrate compliance.

D. Prior to completion of project, an infrared scan of switchgear and panelboard feeder equipment connection shall be performed when all loads are energized.

E. TABLE I: Color Coding for Phase Identification:

1. Color code secondary service, feeder, and branch circuit conductors with factory applied color as follows:

<table>
<thead>
<tr>
<th>208V/120 Volts</th>
<th>Phase</th>
<th>480V/277 Volts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
<td>A</td>
<td>Brown</td>
</tr>
<tr>
<td>Red</td>
<td>B</td>
<td>Orange</td>
</tr>
<tr>
<td>Blue</td>
<td>C</td>
<td>Yellow</td>
</tr>
<tr>
<td>White</td>
<td>Neutral</td>
<td>Gray</td>
</tr>
<tr>
<td>Green</td>
<td>Ground</td>
<td>Green</td>
</tr>
</tbody>
</table>

3.4 FEEDER TESTING

A. Products

1. Material: Contractor shall provide all necessary testing equipment and devices required to perform the test described in this section.

B. Execution

1. Visual and Mechanical Inspection
   a. Inspect cables for physical damage and proper connection in accordance with one-line diagrams.
b. Test cable mechanical connections to manufacturer’s recommended values using a calibrated torque wrench.
c. Check cable color coding with specification section 26 05 53 and National Electrical Code standards.

2. Electrical Tests
   a. Perform insulation-resistance test on each conductor with respect to ground and adjacent conductors. Applied potential shall be 1000 volts dc for 1 minute.
   b. Perform continuity test to insure proper cable connection.

3. Test Values
   a. Evaluate results by comparison with cables of same length and type. Investigate any values less than 50 megohms.
   b. Submit results to Engineer for approval in accordance with Section 26 05 03.

END OF SECTION
PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

B. Division-26 Basic Materials and Methods sections apply to work of this section.

C. Requirements of this section apply to electrical grounding and bonding work specified elsewhere in these specifications.

1.2 SUMMARY

A. Extent of electrical grounding and bonding work is indicated by drawings and schedules and as specified herein. Grounding and bonding work is defined to encompass systems, circuits, and equipment.

B. Type of electrical grounding and bonding work specified in this section includes the following:
   1. Solidly grounded.

C. Applications of electrical grounding and bonding work in this section includes the following:
   1. Underground metal piping.
   2. Underground metal water piping.
   5. Electrical power systems.
   7. Separately derived systems.
   8. Raceways.
   9. Service equipment.
   10. Enclosures.
   11. Equipment.
   12. Lighting Standards.
   13. Landscape Lighting.

D. Refer to other Division-26 sections for wires/cables, electrical raceways, boxes and fittings, and wiring devices which are required in conjunction with electrical grounding and bonding work; not work of this section.

1.3 SUBMITTALS

A. Product Data: Submit manufacturer’s data on grounding and bonding products and associated accessories.

B. Wiring Diagrams: Submit wiring diagrams for electrical grounding and bonding work which indicates layout of ground rods, location of system grounding electrode connections, routing of grounding electrode conductors, also include diagrams for circuits and equipment grounding connections.
C. Submit ground riser diagram for entire project. Show bus bars with transformer ground electrode conductors, etc.

1.4 QUALITY ASSURANCE

A. Manufacturer’s Qualifications: Firms regularly engaged in manufacture of grounding and bonding products, of types, and ratings required, and ancillary grounding materials, including stranded cable, copper braid and bus, grounding electrodes and plate electrodes, and bonding jumpers whose products have been in satisfactory use in similar service for not less than 5 years.

B. Installer’s Qualifications: Firms with at least 5 years of successful installation experience on projects with electrical grounding work similar to that required for project.

C. Codes and Standards:

1. Electrical Code Compliance: Comply with applicable local electrical code requirements of the authority having jurisdiction, and NEC as applicable to electrical grounding and bonding, pertaining to systems, circuits and equipment.

2. UL Compliance: Comply with applicable requirements of UL Standards No.’s 467, Electrical Grounding and Bonding Equipment”, and 869 “Electrical Service Equipment”, pertaining to grounding and bonding of systems, circuits and equipment. In addition, comply with UL Std 486A, “Wire Connectors and soldering Lugs for Use with Copper Conductors.” Provide grounding and bonding products which are UL-listed and labeled for their intended usage.

3. IEEE Compliance: Comply with applicable requirements and recommended installation practices of IEEE Standards 80, 81, 141 and 142 pertaining to grounding and bonding of systems, circuits and equipment.

PART 2 - PRODUCTS

2.1 GENERAL

A. Materials and Components:

1. Provide electrical grounding and bonding system; with assembly of materials, including, but not limited to, cables/wires, connectors, solderless lug terminals, grounding electrodes and plate electrodes, bonding jumper braid, surge arresters, and additional accessories needed for a complete installation. Where more than one type component product meets indicated requirements, selection is installer’s option. Where materials or components are not indicated provide products which comply with NEC, UL, and IEEE requirements and with established industry standards for those applications indicated.

2.2 CONDUCTORS

A. Insulated Conductors: Copper wire or cable insulated for 600V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:

4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductors, 1/4 inch (6 mm) in diameter.
5. **Bonding Conductor:** No. 4 or No. 6 AWG, stranded conductors.
6. **Bonding Jumper:** Copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.
7. **Tinned Bonding Jumper:** Tinned-copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.

C. **Bare Grounding Conductor and Conductor Protector for Wood Poles:**
   1. No. 4 AWG minimum, soft-drawn copper.
   2. **Conductor Protector:** Half-round PVC or wood molding. If wood, use pressure-treated fir or cypress or cedar.

D. **Grounding Bus:** Rectangular bars of annealed copper (1/4 by 3 inches in cross section, unless otherwise indicated; with insulators. Main ground bus bar shall be 24 inches wide. Riser electrical ground bars shall be 12 inches wide.

2.3 **CONNECTORS**

A. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.

B. **Bolted Connectors for Conductors and Pipes:** Copper or copper alloy, bolted pressure-type, with at least two bolts.
   1. **Pipe Connectors:** Clamp type, sized for pipe.

C. **Welded Connectors:** Exothermic-welding kits of types recommended by Cadweld (or approved equal) manufacturer for materials being joined and installation conditions.

2.4 **GROUNDING ELECTRODES**

A. **Ground Rods:** Copper clad steel; 3/4 inch by 10 feet (19 mm by 3 m) in diameter.

B. **Chemical-Enhanced Grounding Electrodes:** Copper tube, straight or L-shaped, charged with nonhazardous electrolytic chemical salts.
   1. **Termination:** Factory-attached No. 4/0 AWG bare conductor at least 48 inches (1200 mm) long.
   2. **Backfill Material:** Electrode manufacturer's recommended material.

**PART 3 – EXECUTION**

3.1 **APPLICATIONS**

A. **Conductors:** Install solid conductor for No.10 AWG and smaller, and stranded conductors for No.8 AWG and larger, unless otherwise indicated.

B. **Underground Grounding Conductors:** Install bare tinned copper conductor, No.3/0 AWG minimum.
   1. Bury at least 24 inches (600 mm) below grade.
   2. **Duct-Bank Grounding Conductor:** Bury 12 inches (300 mm) above duct bank when indicated as part of duct-bank installation.
C. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.

D. Grounding Bus: Install in electrical and telephone equipment rooms, in rooms housing service equipment, and elsewhere as indicated.

1. Install bus on insulated spacers 1 inch (25 mm), minimum, from wall 6 inches (150 mm) above finished floor, unless otherwise indicated.
2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, down to specified height above floor, and connect to horizontal bus.

E. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors, except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.

3.2 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with IEEE C2 grounding requirements

B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches (100 mm) will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches (50 mm) above to 6 inches (150 mm) below concrete. Seal floor opening with waterproof, nonshrink grout.

C. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields as recommended by manufacturer of splicing and termination kits.

D. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No.3/0 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches (150 mm) from the foundation.

3.3 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits. The conduit shall not be acceptable as an equipment ground.

B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:

1. Feeders and branch circuits.
2. Lighting circuits.
3. Receptacle circuits.
5. Three-phase motor and appliance branch circuits.
6. Flexible raceway runs.
7. Armored and metal-clad cable runs.
8. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.
10. Lab Equipment: Provide dedicated insulated equipment grounding conductor in all lab equipment circuits.

C. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

D. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

E. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal in addition to the equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.

F. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.

G. Signal and Communication Equipment: For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.

1. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-by-3-by-12-inch (6-by-76-by-300-mm) grounding bus.
2. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

H. Metal Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

3.4 EXAMINATION

A. Examine areas and conditions under which electrical grounding and bonding connections are to be made and notify Engineer in writing of conditions detrimental to proper completion of work. Do not proceed with work until unsatisfactory conditions have been corrected.
3.5 INSTALLATION OF ELECTRICAL GROUNDING AND BONDING SYSTEMS

A. General: Install electrical grounding and bonding systems in accordance with manufacturer’s instructions and applicable portions of NEC, NECA’s “Standard of Installation”, and in accordance with recognized industry practices to ensure that products comply with requirements.

B. Coordinate with other electrical work as necessary to interface installation of electrical grounding and bonding system work with other work.

C. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

D. Common Ground Bonding with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.

E. Ground Rods: Drive rods until tops are 2 inches (50 mm) below finished floor or final grade, unless otherwise indicated.
   1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating, if any.
   2. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.

F. Test Wells: Ground rod driven through drilled hole in bottom of manholes. Manholes are specified in Division 26 Section "Underground Services and Manholes," and shall be at least 12 inches (300 mm) deep, with cover.
   1. Test Wells: Install at least one test well for each service, unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.

G. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.
   1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
   2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install so vibration is not transmitted to rigidly mounted equipment
   3. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.

H. Grounding and Bonding for Piping:
   1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building’s main service equipment, each unit substation, or each main electrical room grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on
street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.

2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.

3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

I. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.

J. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet (18 m) apart.

K. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each steel column, extending around the perimeter of building.

1. Install tinned-copper conductor not less than No.4/0 AWG for ground ring and for taps to building steel.

2. Bury ground ring not less than 24 inches (600 mm) from building foundation.

L. Ufer Ground (Concrete-Encased Grounding Electrode): Fabricate according to NFPA 70, using a minimum of 20 feet (6m) of bare copper conductor not smaller than No. 4/0 AWG.

1. If concrete foundation is less than 20 feet (6 m) long, coil excess conductor within base of foundation.

2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building grounding grid or to grounding electrode external to concrete.

M. Tighten grounding and bonding connectors and terminals, including screws and bolts, in accordance with manufacturer’s published torque tightening values for connectors and bolts. Where manufacturer’s torquing requirements are not indicated, tighten connections to comply with tightening torque values specified in UL 486A to assure permanent and effective grounding.

N. Apply corrosion-resistant finish to field-connections, buried metallic grounding and bonding products, and places where factory applied protective coatings have been destroyed, which are subjected to corrosive action.

O. Install all connectors on clean metal contact surfaces, to ensure electrical conductivity and circuit integrity.

P. Ground each separately – derived system neutral to:

1. Separate grounding electrode.

2. Building steel and cold water pipe of area served.

Q. Bonding of Steel Roof Structure: Bond ground down conductors to the steel roof structure of the penthouse level.

R. Bonding of Exhaust Stacks: Every exhaust stack shall be bonded to the steel roof structure. Stack shall be bonded at a minimum of two locations each. Bond conductor shall be same size as the down conductors.
3.6 FIELD QUALITY CONTROL

A. Upon completion of installation of electrical grounding and bonding systems, test ground resistance with ground resistance tester. Where tests show resistance to ground is over 5 ohms, take appropriate action to reduce resistance to 5 ohms, or less, by driving additional ground rods; then retest to demonstrate compliance.

END OF SECTION
SECTION 26 05 29
HANGERS AND SUPPORTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Requirements of the following Division 26 Sections apply to this section:
   1. “Electrical Requirements.”

1.2 SUMMARY

A. This Section includes secure support from the building structure for electrical items by means of hangers, supports, anchors, sleeves, inserts, seals, and associated fastenings.

B. Related Sections: The following Sections contain requirements that related to this Section:
   1. Division 3 Section “Mild Steel Concrete Reinforcement” for inserts, anchors, and sleeves to be installed in concrete for use with supporting devices.
   2. Division 5 Section “Metal Fabrications” for requirements for miscellaneous metal items involved in supports and fastenings.
   3. Division 7 Section “Firestopping” for requirements for firestopping at sleeves through walls and floors that are fire barriers.
   4. Refer to Division 26 Sections for additional specific support requirements that may be applicable to specific items.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

B. Product data for each type of product specified.
   1. Hanger and support schedule showing manufacturer’s figure number, size, spacing, features, and application for each required type of hanger, support, sleeve, seal, and fastener to be used.

C. Shop drawings indicating details of fabricated products and materials.

D. Engineered Design consisting of details and engineering analysis for supports for the following items:
   1. Cable Tray. (Refer to technology drawings and Division 27.)
   2. Conduit (racked).
   3. Ceiling mounted boxes, transformers.
   5. Electrical Busway.
1.4 QUALITY ASSURANCE

A. Electrical Component Standard: Components and installation shall comply with NFPA 70 “National Electrical Code.”

B. Electrical components shall be listed and labeled by UL, ETL, CSA, or other approved, nationally recognized testing and listing agency that provides third-party certification follow-up services.

C. Installation shall comply with local authorities seismic requirements.

PART 2 - PRODUCTS

2.1 COATINGS

A. Coating: Supports, support hardware, and fasteners shall be protected with zinc coating or with treatment of equivalent corrosion resistance using approved alternative treatment, finish, or inherent material characteristic. Products for use outdoors shall be hot-dip galvanized.

2.2 MANUFACTURED SUPPORTING DEVICES

A. Raceway Supports: Clevis hangers, riser clamps, conduit straps, threaded C-clamps with retainers, ceiling trapeze hangers, wall brackets, and spring steel clamps.

B. Fasteners: Types, materials, and construction features as follows:

1. Expansion Anchors: Carbon steel wedge or sleeve type.
2. Toggle Bolts: All steel springhead type.

C. Conduit Sealing Bushings: Factory-fabricated watertight conduit sealing bushing assemblies suitable for sealing around conduit, or tubing passing through concrete floors and walls. Construct seals with steel sleeve, malleable iron body, neoprene sealing grommets or rings, metal pressure rings, pressure clamps, and cap screws.

D. Cable Supports for Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug for nonarmored electrical cables in riser conduits. Provide plugs with number and size of conductor gripping holes as required to suit individual risers. Construct body of malleable-iron casting with hot-dip galvanized finish.

E. U-Channel Systems: 16-guage steel channels, with 9/16-inch-diameter holes, at a minimum of 8 inches on center, in top surface. Provide fittings and accessories that mate and match with U-channel and are of the same manufacture.

F. Plastic or fiber anchors are prohibited.

2.3 FABRICATED SUPPORTING DEVICES

A. General: Shop- or field-fabricated supports or manufactured supports assembled from U-channel components.

B. Steel Brackets: Fabricated of angles, channels, and other standard structural shapes. Connect with welds and machine bolts to form rigid supports.
PART 3 - EXECUTION

3.1 INSTALLATION

A. Install supporting devices to fasten electrical components securely and permanently in accordance with NEC requirements.

B. Coordinate with the building structural system and with other electrical installation.

C. Raceway Supports: Comply with the NEC and the following requirements:
   1. Conform to manufacturer’s recommendations for selection and installation of supports.
   2. Strength of each support shall be adequate to carry present and future load multiplied by a safety factor of at least four. Where this determination results in a safety allowance of less than 200 lbs., provide additional strength until there is a minimum of 200 lbs safety allowance in the strength of each support.
   3. Install individual and multiple (trapeze) raceway hangers and riser clamps as necessary to support raceways. Provide U-bolts, clamps, attachments, and other hardware necessary for hanger assembly and for securing hanger rods and conduits.
   4. Support parallel runs of horizontal raceways together on trapeze-type hangers.
   5. Support individual horizontal raceways by separate pipe hangers. Spring steel fasteners may be used in lieu of hangers only for 1-1/2-inch and smaller raceways serving lighting and receptacle branch circuits above suspended ceilings only. For hanger rods with spring steel fasteners, use ¼-inch diameter or larger threaded steel. Use spring fasteners that are specifically designed for supporting single conduits or tubing.
   6. Space supports for raceway in accordance with NEC.
   7. Support exposed and concealed raceway within 1 foot of an unsupported box and access fittings. In horizontal runs, supports at the box and access fittings may be omitted where box or access fittings are independently supported and raceway terminals are not made with chase nipples of threadless box connectors.
   8. In vertical runs, arrange support so the load produced by the weight of the raceway and the enclosed conductors is carried entirely by the conduit supports with no weight load on raceway terminals.
   9. Attaching to ceiling support wires, mechanical piping, ductwork or plumbing piping is prohibited.

D. Vertical Conductor Supports: Install simultaneously with installation of conductors (i.e., strain reliefs).

E. Miscellaneous Supports: Support miscellaneous electrical components as required to produce the same structural safety factors as specified for raceway supports. Install metal channel racks for mounting cabinets, panelboards, disconnects, control enclosures, pull boxes, junction boxes, transformers, and other devices.

F. In open overhead spaces, cast boxes threaded to raceways need not be supported separately except where used for fixture support; support sheet metal boxes directly from the building structure or by bar hangers. Where bar hangers are used, attach the bar to the raceways on opposite sides of the box and support the raceway with an approved type of fastener not more than 24 inches from the box.

G. Electrical Busways: Vertical runs of plug in busway shall be supported at the floor per manufacturer’s recommendation. Horizontal runs shall conform to requirement of Paragraph C above.

H. Sleeves: Install in concrete slabs and walls and all other fire-rated floors and wall for raceways and cable installations. For sleeves through fire-rated wall or floor construction, apply UL-listed
firestopping sealant in gaps between sleeves and enclosed conduits and cables in accordance with “Fire Stopping” requirement of Division 7.

I. Conduit Seals: Install seals for conduit penetrations of slabs on grade and exterior walls below grade and where indicated. Tighten sleeve seal screws until sealing grommets have expanded to form watertight seal.

J. Fastening: Unless otherwise indicated, fasten electrical items and their supporting hardware securely to the building structure, including but not limited to conduits, raceways, cables, cable trays, cabinets, panelboards, transformers, boxes, disconnect switches, and control components in accordance with the following:

1. Fasten by means of wood screws or screw-type nails on wood, toggle bolts on hollow masonry units, concrete inserts or expansion bolts on concrete or masonry, and machine screws, welded threaded studs, or spring-tension clamps on steel. Do not weld conduit, pipe straps, or items other than threaded studs to steel structures. In partitions or light steel construction, use sheet metal screws.
2. Holes cut to depth of more than 1-1/2 inches in reinforced concrete beams or to depth of more than ¾ inch in concrete shall not cut the main reinforcing bars. Fill holes that are not used.
3. Ensure that the load applied to any fastener does not exceed 25 percent of the proof test load. Use vibration- and shock-resistant fasteners for attachments to concrete slabs.

K. TESTS: Test pull-out resistance of one of each type, size, and anchorage material for the following fastener types:

1. Expansion anchors.
2. Toggle bolts.

L. Provide all jacks, jigs, fixtures, and calibrated indicating scales required for reliable testing. Obtain the structural Engineer’s approval before transmitting loads to the structure. Test to 90 percent of rated proof load for fastener. If fastening fails test, revise all similar fastener installations and retest until satisfactory results are achieved.

END OF SECTION
SECTION 26 05 33
RACEWAYS AND BOXES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this section.

B. Requirements of the following Division 26 Sections apply to this Section:

1. Division 26 Section “Electrical Requirements.”
2. Division 26 Section “Basic Material and Methods”
3. Division 7 Section “Firestopping” for requirements for firestopping at sleeves through walls and floors that are fire barriers.

1.2 SUMMARY

A. Drawings are diagrammatic. All bends, boxes, fittings, couplings are not necessarily shown. Supply as necessary to comply with the National Electric Code.

B. This Section includes raceways for electrical wiring. Types of raceways, boxes and fittings in this section include the following:

1. Electrical metallic tubing (EMT).
2. Flexible metal conduit.
3. Intermediate metal conduit (IMC).
4. Liquid-tight flexible conduit.
5. Rigid metallic conduit (RMC).
7. Rigid non-metallic conduit.
8. Electrical non-metallic tubing (ENT)
9. Wireway.
10. Outlet boxes.
12. Pull boxes.
14. Locknuts.
15. Knockout closures.

C. Related Sections: The following section contains requirements that relate to this section:

1. Division 26 Section “Raceway and Boxes” for conduit connectors, fittings, and couplings.
2. Division 7 Section “Firestopping” for conduit penetrations through rated walls and slabs.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of contract and Division 1 Specification Section.

B. Product Data for the following products:

1. Raceways and fittings.
2. Wireways and fittings.
3. Boxes and fittings.

C. Installation Instructions: Manufacturer’s written installation instructions for wireway, surface raceway, and nonmetallic raceway products.

D. Product data and material safety data sheets (MSDS) for sealants used on the interior of the building indicating chemical composition and VOC content of each product used.

1.4 QUALITY ASSURANCE

A. Electrical Component Standard: Components and installation shall comply with NFPA 70 “National Electrical Code.”

B. NEMA Compliance: Comply with applicable requirements of NEMA standards pertaining to raceways.

C. UL Compliance and Labeling: Comply with applicable requirements of UL standards pertaining to electrical raceway systems. Provide raceway products and components listed and labeled by UL.

D. Manufacturers: Firms regularly engaged in manufacture of electrical boxes and fittings, of types, sizes, and capacities required, whose products have been in satisfactory use in similar service for not less than five years.

E. Installer’s Qualifications: Firms with at least five years of successful installation experience on projects utilizing electrical boxes and fittings similar to those required for this project.

F. NEC Compliance: Comply with NEC as applicable to construction and installation of electrical wiring boxes and fittings.

G. UL Compliance: Comply with applicable requirements of UL 50, UL 514-Series, and UL 886 pertaining to electrical boxes and fittings. Provide electrical boxes and fittings which are UL-listed and labeled.

H. NEMA Compliance: Comply with applicable requirements of NEMA Stds/Pub No.’s OS1, OS2 and PUB 250 pertaining to outlet and device boxes, covers and box supports.

I. Federal Specification Compliance: Comply with applicable requirements of FS W-C 586, “Electrical Cast Metal Conduit Outlet Boxes, Bodies, and Entrance Caps.”

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND TUBING

A. Rigid Steel Conduit: ANSI C80.1

B. Intermediate Steel Conduit: UL 1242.

C. Electrical Metallic Tubing and Fittings: ANSI C80.3.

D. Flexible Metal Conduit: UL 1, zinc-coated steel.

E. Liquid-tight Flexible Metal Conduit and Fittings: UL 360.
2.2 METAL CLAD CABLE, TYPE MC
   A. MC Cable is prohibited.

2.3 NONMETALLIC CONDUIT AND DUCTS
   A. Rigid Nonmetallic Conduit (RNC): NEMA TC 2 and UL 651, Schedule 40 or 80 PVC.
   B. PVC Conduit and Tubing Fittings: NEMA TC 3; match to conduit or conduit/tubing type and material.
   C. Conduit, Tubing and Duct Accessories: Types, sizes and materials complying with manufacturer's published product information. Mate and match accessories with raceway.
   D. Electrical non-metallic tubing (ENT): NEMA TC13 and UL1653.

2.4 CONDUIT BODIES AND FITTINGS
   A. General: Types, shapes, and sizes as required to suit individual applications and NEC requirements. Provide matching gasketed covers secured with corrosion-resistant screws.
   B. Metallic Conduit and Tubing: Use metallic conduit bodies. Use bodies with threaded hubs for threaded raceways.
   C. EMT Conduit Bodies: Use bodies with steel set screw connectors and couplings for interior applications and steel compression gland connectors and couplings for vivarium area and exterior applications.
   D. Nonmetallic Conduit and Tubing: Use nonmetallic conduit bodies conforming to UL514B.
   E. Liquid-Tight Flexible Conduit Fittings: With threaded grounding cone, a steel, nylon or equal plastic compression ring, and a gland for tightening. Either steel or malleable iron only with insulated throats and male thread and locknut or male bushing with or without O-ring seal. Each connector shall provide a low resistance ground connection between the flexible conduit and the outlet box, conduit or other equipment to which it is connected.
   F. Bushings: Insulated type, designed to prevent abrasion of wires without impairing the continuity of the conduit grounding system, for rigid steel conduit, IMC and EMT, larger than ¾” size.
   G. Expansion Fittings: Each conduit that is buried in or secured to the buildings construction on opposite sides of a building expansion joint and each long run of exposed conduit that may be subject to excessive stresses shall be provided with an expansion fitting. Expansion fittings for rigid steel conduit shall be hot-dipped galvanized malleable iron with factory installed packing and a grounding ring. Expansion fittings for rigid non-metallic conduit shall be of the short type in runs 25’ or less, and the long type in runs 26’ to 80’. The long type shall be a two piece barrel and piston joint, providing 6” of the total movement range in ¾” through 6” conduit sizes. The short type shall be a one piece, coupling with O-ring, providing 2” of total movement range in ¾” to 2” conduit sizes.
   H. Seal Off Fittings: Threaded, zinc or cadmium coated, cast or malleable iron type for steel conduits. Fittings used to prevent passage of water vapor shall be of the continuous drain type.

2.5 WIREWAYS
   A. General: Electrical wireways shall be of NEMA types and sizes as indicated. Fittings and accessories including but not limited to couplings, offsets, elbows, expansion joints, adapters,
hold-down straps, and end caps shall match and mate with wireway as required for complete system. Where features are not indicated, select to fulfill wiring requirements and comply with applicable provisions of NEC.

B. Wireway covers shall be hinged type.

### 2.6 FABRICATED MATERIALS - BOXES

**A. Outlet Boxes:** Provide galvanized flat rolled sheet-steel outlet wiring boxes, of shapes, cubic inch capacities, and sizes (minimum 4 inch square, 1 ½ inch deep), including box depths as required, suitable for installation at respective locations. Construct outlet boxes with mounting holes, and with cable and conduit-size knockout openings in bottom and sides. Provide boxes with threaded screw holes, with corrosion-resistant cover and grounding screws for fastening surface and device type box covers, and for equipment type grounding.

1. **Outlet Box Accessories:** Provide outlet box accessories as required for each installation, including box supports, mounting ears and brackets, wallboard hangers, box extension rings, fixture studs, cable clamps and metal straps for supporting outlet boxes, which are compatible with outlet boxes being used to fulfill installation requirements for individual wiring situations. Choice of accessories is Installer's code-compliance option.

**B. Device Boxes:** Provide galvanized coated flat rolled sheet-steel non-gangable device boxes, of shapes, cubic inch capacities, and sizes (minimum 4 inch square, 1 ½ inches deep), including box depths as indicated, suitable for installation at respective locations. Construct device boxes for flush mounting with mounting holes, and with conduit-size knockout openings in bottom and ends, and with threaded screw holes in end plates for fastening devices. Provide conduit connectors and corrosion-resistant screws for equipment type grounding.

1. **Device Box Accessories:** Provide device box accessories as required for each installation, including mounting brackets, device box extensions, switch box supports, plaster ears, and plaster ears, and plasterboard expandable grip fasteners, which are compatible with device boxes being utilized to fulfill installation requirements for individual wiring situations. Choice of accessories is Installer’s code-compliance option.

**C. Raintight Outlet Boxes:** Provide corrosion-resistant cast-metal raintight outlet wiring boxes, of types, shapes and sizes, including depth of boxes, with threaded conduit holes for fastening electrical conduit, cast-metal face plates with spring-hinged watertight caps suitably configured for each application, including face plate gaskets and corrosion-resistant plugs and fasteners.

**D. Junction and Pull Boxes:** Provide galvanized code-gauge sheet steel junction and pull boxes, with screw-on covers; of types, shapes and sizes, to suit each respective location and installation; with welded seams and equipped with stainless steel nuts, bolts, screws, and washers. Pull boxes installed in finished spaces must be flush mounted cabinets provided with trim, hinged door and flush latch and lock to match flush mounted panelboard trim.

**E. Exterior junction or pull boxes, flush with grade:**

1. Exterior junction or pull boxes are not permitted without written approval from UCB Facilities Engineer.

**F. Bushings, Knockout Closures and Locknuts:** Provide corrosion-resistant box knockout closures, conduit locknuts and malleable iron conduit bushings, offset connectors, of types and sizes, to suit respective installation requirements and applications.
2.7 VOC CONTENT

A. Sealants used on the interior building shall comply with VOC limits as seen in section 01 81 13 – Sustainable Design Requirements.

PART 3 - EXECUTION

3.1 WIRING METHOD

A. Outdoors: Use the following wiring methods:

5. Connection to Vibrating Equipment including transformers, pneumatic or electrical solenoid, and motor-operated equipment: Liquid-tight flexible metal conduit.

B. Indoors: Use the following wiring methods:

1. Exposed (below 10 ft. to floor): Intermediate metal conduit, rigid steel conduit.
2. Exposed (above 10ft. or in electrical room): Electrical metallic tubing.
4. Connection to Vibrating Equipment including transformers, pneumatic or electrical solenoid, and motor-operated equipment: Flexible metal conduit.
5. Connection to Vibrating Equipment in Moist/Humid or Corrosive Atmosphere including pneumatic or electric solenoid, and motor-operated equipment: Liquid-tight flexible metal conduit.
6. Raceway mounted to underside of metal-corrugated sheet roof decking shall be Rigid Metal Conduit or intermediate Metal Conduit.

3.2 INSTALLATION OF RACEWAYS

A. General: Install electrical raceways in accordance with manufacturers’ written installation instructions, applicable requirements of NEC, and as follows.

B. For all power receptacle circuits and lighting circuits, the minimum conduit size shall be ¾”.

C. Conceal conduit and EMT, unless indicated otherwise, within finished wall, ceilings, and floors. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot water pipes. Install raceways level and square and at proper elevations.

D. Elevation of Raceway: Where possible, install horizontal raceway runs above water and steam piping.

E. Complete installation of electrical raceways before starting installation of conductors within raceways.

F. Provide supports for raceways as specified elsewhere in Division 26 and in accordance with NEC and local authorities seismic requirements.

G. Prevent foreign matter from entering raceways by using temporary closure protection.
H. Protect stub-ups from damage where conduits rise from floor slabs. Arrange so curved portion of bends is not visible above the finished slab. All elbow penetration through the slab shall be PVC coated rigid metallic conduit Ells.

I. Make bends and offsets so the inside diameter is not effectively reduced. Unless otherwise indicated, keep the legs of a bend in the same plane and the straight legs of offsets parallel.

J. Use raceway fittings that are of types compatible with the associated raceway and suitable for the use and location. For intermediate steel conduit, use threaded rigid steel conduit fittings except as otherwise indicated.

K. Run concealed raceways with a minimum of bends in the shortest practical distance considering the type of building construction and obstructions except as otherwise indicated.

L. Raceways embedded in slabs shall only be permitted with the strict written approval of the Structural Engineer and Architect. For bidding purpose, conduit shall not be permitted in slab.

M. Install exposed raceways parallel and perpendicular to nearby surfaces or structural members and follow the surface contours as much as practical. All exposed conduit runs shall be approved by the Architect prior to installing.

N. All exposed conduits in public areas shall be painted to match surrounding walls. Verify exact color with the Architect. Painting specified herein shall be provided by others.

O. Run exposed, parallel, or banked raceways together. Make bends in parallel or banked runs from the same center line so that the bends are parallel. Factory elbows may be used in banked runs only where they can be installed parallel. This requires that there be a change in the plane of the run such as from wall to ceiling and that the raceways be of the same size. In other cases, provide field bends for parallel raceways. All exposed conduit routing shall be approved by the Architect prior to installing.

P. Join raceways with fittings designed and approved for the purpose and make joints tight. Where joints cannot be made tight, use bonding jumpers to provide electrical continuity of the raceway system. Make raceway terminations tight. Where terminations are subject to vibration, use bonding bushings or wedges to assure electrical continuity. Where subject to vibration or dampness, use insulating bushings to protect conductors. Use expansion fittings at building expansion joints.

Q. Tighten set screws of threadless fittings with suitable tool.

R. Terminations: Where raceways are terminated with locknuts and bushings, align the raceway to enter squarely and install the locknuts with dished part against the box. Where terminations cannot be made secure with one locknut, use two locknuts, one inside and one outside of the box. All conduit connections to junction boxes shall have insulated bushings.

S. Where terminating in threaded hubs, screw the raceway or fitting tight into the hub so the end bears against the wire protection shoulder. Where chase nipples are used, align the raceway so the coupling is square to the box, and tighten the chase nipple so no threads are exposed.

T. Install pull wires in empty raceways. Use No. 14 AWG zinc-coated steel or monofilament plastic line having not less than 200-lb tensile strength. Leave no less than 12 inches of slack at each end of the pull wire.

U. Install raceway sealing fittings in accordance with the manufacturer’s written instructions. Locate fittings at suitable, approved, accessible locations and fill them with UL-listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover.
Install raceway sealing fittings at the following points and elsewhere as indicated:

1. Where conduits pass from warm locations to cold locations, such as the boundaries of refrigerated spaces, air-conditioned spaces and walk-in coolers.
2. Where required by the NEC.

V. Stub-up Connections: Extend conduits through concrete floor for connection to freestanding equipment with an adjustable top or coupling threaded inside for plugs and set flush with the finished floor. Extend conductors to equipment with rigid steel conduit; flexible metal conduit may be used 6 inches above the floor. Where equipment connections are not made under this contract, install screwdriver-operated threaded flush plugs flush with floor.

W. Flexible connection: Use length (maximum of 6 ft.) of flexible conduit for recessed and semi-recessed lighting fixtures, for equipment subject to vibration, noise transmission, or movement; and for all motors. Use liquid-tight flexible conduit in wet locations. Install separate equipment grounding conductor across flexible connections.

X. Install nonferrous conduit or tubing for circuits operating above 60 Hz.

Y. PVC externally coated rigid steel conduit: Use only fittings approved for use with that material. Patch all nicks and scrapes in PVC coating after installing conduit.

Z. All underground conduits shall be installed a minimum of 48 inches below finish grade for medium voltage feeders and 30 inches for 480 volt feeders. All other conduits shall be installed in accordance with the NEC and coordinated depth with other trades.

AA. Grounding: Install a separate green equipment grounding conductor in all raceways from the panelboard/junction box supplying the raceway to the receptacle or equipment ground terminals. Conduits will not be permitted as a ground conductor.

BB. Emergency feeder raceways than are not concealed in the electrical room shall be wrapped in a 1-hour protected fire wrap (MFR: 3M interam wrap or approved equal).

3.3 INSTALLATION OF ELECTRICAL BOXES AND FITTINGS

A. General: Install electrical boxes and fittings in accordance with manufacturer’s written instructions, applicable requirements of NEC and NECA’s “Standard of Installation,” and in accordance with recognized industry practices to fulfill project requirements.

B. Coordinate installation of electrical boxes and fittings with wire/cable, wiring devices, and raceway installation work.

C. Provide raintight “in use” outlets for interior and exterior locations exposed to weather or moisture.

D. Provide knockout closures to cap unused knockout holes where blanks have been removed.

E. Install electrical boxes in those locations which ensure ready accessibility to enclosed electrical wiring.

F. Installing boxes back-to-back in walls shall not be permitted. Provide no less than 12 inches (150 mm) of separation.

G. Position recessed outlet boxes accurately to allow for surface finish thickness.
H. Avoid using round boxes where conduit must enter box through side of box, which would result in difficult and insecure connections when fastened with locknut or bushing on rounded surfaces.

I. Fasten electrical boxes firmly and rigidly to substrates, or structural surfaces to which attached, or solidly embedded electrical boxes in concrete or masonry.

J. Provide electrical connections for installed boxes.

K. Subsequent to installation of boxes, protect boxes from construction debris and damage.

3.4 GROUNDING

A. Upon completion of installation work, properly ground electrical boxes and demonstrate compliance with requirements.

3.5 ADJUSTING AND CLEANING

A. Upon completion of installation of raceways, inspect interiors of raceways; clear all blockages and remove burrs, dirt, and construction debris.

END OF SECTION
SECTION 26 05 53
IDENTIFICATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Requirements of the following Division 26 Sections apply to this Section:
   1. “Electrical Requirements.”

1.2 SUMMARY

A. This Section includes identification of electrical materials, equipment, and installations. It includes requirements for electrical identification components including but not limited to the following:
   1. Buried electrical line warnings.
   2. Identification labeling for raceways, cables, and conductors.
   3. Operational instruction signs.
   4. Warning and caution signs.
   5. Equipment labels and signs.

B. Related Sections: The following Sections contain requirements that relate to this Section;
   1. Division 9 Section “Painting” for related identification requirements.
   2. Division 26 Section “Electrical Power Conductors and Cables” for requirements for color coding of conductors for phase identification.

C. Refer to other Division 26 Sections for additional specific electrical identification associated with specific items.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

B. Product Data for each type of product specified.

C. Schedule of identification nomenclature to be used for identification signs and labels.

D. Samples of engraved, plastic laminate to be used on switchgear, switchboards, disconnect switches and panelboards.

1.4 QUALITY ASSURANCE

A. Electrical Component Standard: Components and installation shall comply with NFPA 70 “National Electrical Code.”

B. ANSI Compliance: Comply with requirements of ANSI Standard A13.1, “Scheme for the identification of Piping Systems,” with regard to type and size of lettering for raceway and cable labels.
PART 2 - PRODUCTS

2.1 ELECTRICAL IDENTIFICATION PRODUCTS

A. Colored Adhesive Marking Tape for Raceways, Wires, and Cables: Self-adhesive vinyl tape not less than 3 mil thick by 1 inch to 2 inches in width.

B. Underground Line Marking Tape: Permanent, bright-colored, continuous-printed, plastic tape with magnetic tracer strip not less than 6 inches wide by 4 mil thick. Printed legend indicative of general type of underground line below.

C. Wire/Cable Designation Tape Markers: Vinyl or vinyl-cloth, self-adhesive, wrap around, cable/conductor markers with preprinted numbers and letters.

D. Engraved, Plastic-Laminated Labels, Signs, and Instruction Plates: Engraving stock melamine plastic laminate, 1/16-inch minimum thick for sign up to 20 square inches, or 8 inches in length; 1/8-inch thick for larger sizes. Engraved legend in black letters on white face for normal power and red letters on white face for emergency and standby power. Plastic laminate shall be punched for mechanical fasteners.

E. Baked-Enamel Warning and Caution Signs for Interior Use: Preprinted aluminum signs, punched for fasteners, with colors, legend, and size appropriate to the location.

F. Exterior Metal-Backed Butyrate Warning and Caution Signs: Weather-resistant, non-fading, preprinted cellulose acetate butyrate signs with 20-gage, galvanized steel backing, with colors, legend, and size appropriate to the location. Provide ¼-inch grommets in corners for mounting.

G. Fasteners for Plastic-Laminated and Metal Signs: Self-tapping stainless steel screws or number 10/32 stainless steel machine screws with nuts and flat and lock washers.

H. Cable Ties: Fungus-inert, self-extinguishing, one-piece, self-locking nylon cable ties, 0.18-inch minimum width, 50-lb minimum tensile strength, and suitable for a temperature range from minus 50°F to 350°F. Provide ties in specified colors when used for color coding.

I. Electronic Labels: Self-adhesive, 3/16 inch industrial label, black on clear for normal circuits and red on clear for emergency/standby circuits. Acceptable manufacturers include the following:
   1. Kroy
   2. Brother

PART 3 - EXECUTION

3.1 INSTALLATION

A. Lettering and Graphics: Coordinate names, abbreviations, colors, and other designations used in electrical identification work with corresponding designations specified or indicated. Install numbers, lettering, and colors as approved in submittals and as required by code.

B. Install identification devices in accordance with manufacturer's written instructions and requirements of NEC.

   1. Degrease and clean surfaces to receive nameplates and labels.
   2. Install nameplates parallel to equipment lines.
   3. Secure nameplates to equipment using screws or rivets. Locate nameplates on outside face of panelboard doors in finished locations.
C. Sequence of Work: Where identification is to be applied to surfaces that require finish, install identification after completion of finish work.

3.2 CONDUIT IDENTIFICATION

A. Identify Junction, Pull, and Connection Boxes: Code-required caution sign for boxes shall be pressure-sensitive, self-adhesive label indicating system voltage in black, preprinted on orange background. Install on outside of box cover. Also label box covers with identity of contained circuits. Use pressure-sensitive plastic labels at exposed locations and similar labels at concealed boxes.

B. Underground Electrical Line Identification: During trench backfilling, for underground power, signal, and communications lines, install continuous underground plastic line marker, located directly above line at 6 to 8 inches below finished grade. Where multiple lines installed in a common trench or concrete envelope do not exceed an overall width of 16 inches; install a single line marker.

C. Install line marker for underground wiring, both direct-buried and in raceway.

D. Identify Raceways of Certain Systems with Color Banding: Band exposed or accessible raceways of the following systems for identification. Bands shall be painted with colors indicated below. Make each color band 2 inches wide, completely encircling conduit, and place adjacent bands of two-color markings in contact, side by side. Install bands at changes in direction, at penetrations of walls and floors, and at 40-foot maximum intervals in straight runs. Apply the following colors:

2. Emergency Circuitry: Yellow.
4. Mechanical and Electrical Supervisory System: Green and Blue.
5. Telephone System: Green.
8. Television: Violet.
9. Tag or label conductors as follows:
   a. Future Connections: Conductors indicated to be for future connection or connection under another contract with identification indicating source and intent.
   b. Multiple Circuits: Where multiple branch circuits or control wiring or communications/signal conductors are present in the same box or enclosure label each conductor or cable. Provide label on each box indicating source, voltage, circuit number, and phase for branch circuit wiring. Phase and voltage of branch circuit wiring may be indicated by mean of coded color of conductor insulation. For control and communications/signal wiring, use color coding or wire/cable marking tape at terminations and at intermediate locations where conductors appear in wiring boxes, troughs, and control cabinets. Use consistent letter/number conductor designations throughout on wire/cable marking tapes.
   c. Match identification markings with designations used in panelboards shop drawings, Contract Documents, and similar previously established identification schemes for the facilities’ electrical installations.

E. Install labels at locations indicated and at locations for best convenience of viewing without interference with operation and maintenance of equipment.
F. Conductor Color Coding: Provide color coding for secondary service, feeder, and branch circuit conductors throughout the project secondary electrical system as follows:

<table>
<thead>
<tr>
<th>208/120 Volts</th>
<th>Phase</th>
<th>480/277 Volts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
<td>A</td>
<td>Brown</td>
</tr>
<tr>
<td>Red</td>
<td>B</td>
<td>Orange</td>
</tr>
<tr>
<td>Blue</td>
<td>C</td>
<td>Yellow</td>
</tr>
<tr>
<td>White</td>
<td>Neutral</td>
<td>Gray</td>
</tr>
<tr>
<td>Green</td>
<td>Ground</td>
<td>Green</td>
</tr>
</tbody>
</table>

G. Use conductors with color factory-applied the entire length of the conductors except as follows:

1. The following field-applied color-coding methods may be used in lieu of factory-coded wire for sizes larger than No. 10 AWG:
   a. Apply colored, pressure-sensitive plastic tap in half-lapped turns for a distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply the last two laps of tape with no tension to prevent possible unwinding. Use 1-inch-wide tape in colors as specified. Do not obliterate cable identification markings by taping. Tape locations may be adjusted slightly to prevent such obliteration.
   b. In lieu of pressure-sensitive tape, colored cable ties may be used for color identification. Apply three ties of specified color to each wire at each terminal or splice point starting 3 inches from the terminal and spaced 3 inches apart. Apply with a special tool or pliers, tighten for snug fit, and cut off excess length.

2. All grounded conductors No. 6 AWG and smaller shall be a factory applied color across the entire length of conductors.

H. Power Circuit Identification:

1. Securely fasten wrap-around marker bands to cables, feeders, and power circuits in pull boxes, junction boxes, and switchgear rooms.

I. Apply warning, caution, and instruction signs and stencils as follows:

1. Install warning, caution, or instruction signs where required by NEC where indicated, or where reasonably required to assure safe operation and maintenance of electrical systems and of the items to which they connect. Install engraved plastic-laminated instruction signs with approved legend where instructions or explanations are needed for system or equipment operation. Install butyrate signs with metal backing for outdoor items.

2. Emergency Operating Signs: Install engraved laminate signs with white legend on red background with minimum 3/8-inch high lettering for emergency instructions on power transfer, load shedding, or other emergency operations.

J. Install equipment/system circuit/device identification as follows:

1. Apply equipment identification labels of engraved plastic-laminate on each major unit for electrical equipment in the facility including central or master unit of each electrical system. This includes communication/signal/alarm system, unless unit is specified with its own self-explanatory identification. Except as otherwise indicated, provide single line of text, with 3/8-inch-high lettering on 1-1/2-inch-high label (2-inch-high where two lines are required), black lettering in white field for normal power and red lettering on white field for emergency and standby power. Text shall match terminology and numbering of the Contract Documents and shop drawings. Apply labels for each unit of the following categories of electrical equipment:
   a. Panelboards, electrical cabinets, and enclosures.
   b. Access doors and panels for concealed electrical items.
   c. Electrical switchgear and switchboards.
d. Motor starters.
e. Pushbutton stations.
f. Power transfer equipment.
g. Contactors.
h. Remote-controlled switches.
i. Dimmers.
j. Control devices.
k. Transformers.
l. Power generating units.
m. Telephone switching equipment.
n. Fire alarm master station or control panel.
o. Lighting control panel.
p. Static uninterruptable power supply

2. Apply electronic label on the outside of all receptacle and switch plates. The labels shall identify circuit and panelboard.

K. Apply circuit/control/item designation labels of engraved plastic laminate for disconnect switches, breakers, pushbuttons, pilot lights, motor control centers, and similar items for power distribution and control components above, except panelboards and alarm/signal components, where labeling is specified elsewhere. For panelboards, provide framed, typed circuit schedules with explicit description and identification (including room numbers) of items controlled by each individual breaker.

L. Electrical Service Room Distribution Placard: In each of the main electrical rooms, provide a single line riser diagram placard of the entire electrical distribution fed from that room. The placard shall also identify where other services are located per NEC 230.2(e). The riser diagram shall be framed under glass and mounted on the wall in the electrical room. The print shall be of diffusion transfer process to eliminate fading.

END OF SECTION
SECTION 26 09 33
LIGHTING DIMMING AND LIGHTING CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections apply to work of this section.

B. Division-26 Basic Electrical Materials and Methods sections apply to work specified in this section.

1.2 SUMMARY

A. Provide and install dimming lighting controls as shown on drawings and as described in these Specifications.

B. Provide interface module for each dimming lighting control specified in this Section with the Network Lighting Control System specified in Section 26 09 43.

C. Provide all lighting controls as shown, completely wired, operative and securely attached to supports.

D. Where a catalog number and a narrative or pictorial description are provided, the written description shall take precedence and prevail.

E. General Contractor shall provide electrical subcontractor with entire lighting control specification (including illustrations and sketches); electrical subcontractor shall provide each specified manufacturer with complete information about the lighting controls they will supply.

F. Type of lighting controls shall be as indicated alphanumerically and as specified.

G. Lighting control details shown may be modified by the manufacturer provided all of the following conditions have been met:

1. Lighting control performance is equal or improved;
2. Performance of fixtures connected to lighting control is equal or improved;
3. Structural, mechanical, electrical, safety, and maintenance characteristics are equal or improved.
4. Cost to the Owner is reduced or equal.
5. Modifications have been reviewed by the Architect and have been approved by the Architect in writing.

1.3 SUBMITTALS

A. For standard catalog items with no modifications, submit catalog cut sheets prepared by the manufacturer. Cut sheets to clearly show all elements to be supplied and all corresponding product data (including dimming range, lamp and ballast compatibility, voltage, faceplate design and finish, accessories, options, all dimensions and any miscellaneous items detailed in the written description of the specification). If a cut sheet shows more than one (1) product, all non-applicable information shall be crossed out.

B. For standard cataloged lighting controls submit a complete list of materials, including catalog or part numbers, load schedule, address description, function and location.
C. For custom lighting controls submit a reproducible shop drawing prepared by the manufacturer and drawn to scale. Shop drawing to include the name and location of the project. Indicate all corresponding product data including all elements to be supplied, dimming range, lamp and ballast compatibility, voltage, faceplate design and finish, accessories, options, all dimensions and any miscellaneous items detailed in the written description of the specification.

D. For all submittals under paragraphs A through C above, manufacturer shall provide submittals within two weeks of receipt of order. All submittals shall have project name and lighting control type clearly shown.

E. Lighting control cuts and shop drawings shall be submitted in quantities and formats as described in the General Conditions Section of these Specifications.

F. The Engineer and Architect shall make the final determination as to whether or not the submittal contains sufficient information and reserves the right to request a shop drawing if the lighting control cut is insufficient.

1.4 SUBSTITUTIONS

A. Bidders' attention is called to the following procedure to be followed in submitting alternate lighting control manufacturers to those specified:

1. Request for approval shall be accompanied by working lighting control samples (with appropriate mechanical and electrical data, list of materials and finishes and unit cost to the Owner) of both the specified brand and the proposed substitutes as required to make complete comparison and evaluation. These samples shall be in addition to those required by these Specifications. The above data shall be delivered separately to the Architect and Engineer. The samples may be required to be furnished and installed, at the bidder's expense, at a location selected by the Architect. In addition, the bidder shall furnish the Architect and the Engineer with the name and location of at least one completed project where each proposed substitute has been in operation for a period of at least one year (12) months, as well as the names and addresses of the Owner, the Architect and the Lighting Designer.

1.5 QUALITY ASSURANCE

A. All lighting controls and assembled components shall be new, of good quality, and be approved by and bear the label of UL or other approved testing agency (i.e. CSA, ETL) unless otherwise specified in writing.

B. All lighting controls shall meet all required local, state and/or national building, electrical and energy codes and regulations.

1.6 CUSTOMER SUPPORT SERVICES

A. Commissioning: The manufacturer shall supply factory-trained representatives to commission the lighting control system. They shall verify that the contractor has properly installed and interconnected all supplied components. They shall start up all equipment and demonstrate that it meets the requirements of this specification.

B. Training: As part of the commissioning procedures, the manufacturer shall train the owner’s representatives in the operation of the system.

C. Technical Support: The manufacturer shall supply telephone support at no additional cost to the owner for the duration of the warranty period.
D. Replacement components: The manufacturer shall be able to ship replacement parts within 24 hours for any component that fails during the warranty period.

E. Extended Service Coverage: Maintenance agreements shall be available from the manufacturer to provide service for the system both during and after the warranty period.

1.7 WARRANTIES

A. All lighting controls, including parts and workmanship, shall have a warranty of a minimum of one year after the acceptance of the project by the Owner. Any lighting controls found to be defective during the warranty period will be repaired or replaced at no cost to the Owner.

1.8 DELIVERY, STORAGE AND HANDLING

A. Deliver lighting control equipment and components in factory-fabricated type containers or wrappings, which properly protect equipment from damage.

B. Store lighting control equipment in original packaging and protect from weather and construction traffic. Wherever possible, store indoors; where necessary to store outdoors, store above grade and enclose with watertight wrapping.

C. Handle lighting control equipment carefully to prevent physical damage to equipment and components. Do not install damaged equipment; remove from site and replace damaged equipment with new.

PART 2 - PRODUCTS

2.1 GENERAL MATERIAL REQUIREMENTS

A. Acceptable manufacturer: Lutron, ETC or approved equal.

B. Manufacturer’s Qualifications: The basis of design is Lutron Grafic Eye 4000 series. Similar systems from other manufacturers that meet the functional and performance requirements listed herein will be considered. A detailed line-by-line compliance comparison shall be submitted for the Engineer’s review of any alternate system. It is the sole responsibility of the Electrical contractor to ensure that all equipment meets the specifications.

C. Lighting controls shall be fully compatible with all specified fixtures, lamps, transformers and ballasts.

D. Unless otherwise specified, all lighting controls shall be by the same manufacturer.

1. The listing of a manufacture as “acceptable” does not imply automatic approval. It is the responsibility of the Contractor to ensure that any price quotations received and submittals are made for devices that meet or exceed these Specifications.

E. Lighting controls shall operate at the voltage shown in the LIGHTING FIXTURE SCHEDULE and confirmed on the electrical drawings.

F. Dimmers and preset dimming lighting controls shall operate the following sources/load types with a smooth continuous Square Law dimming curve. Dimmers shall also be capable of operating these sources on a non-dim basis. Dimmers shall be electronically assigned to the
appropriate load type/dimming curve and can be reassigned at any time. Universal-type
dimmers that do not adjust the dimming curve shall not be acceptable.

1. Incandescent, Tungsten and Magnetic Low Voltage Transformer
   a. Dimmer shall contain circuitry specifically designed to control and provide a
      symmetrical AC waveform to the input of magnetic low voltage transformers.
   b. Dimmer shall not cause a magnetic low voltage transformer to operate above the
      transformer’s rated operating current and temperature.
   c. Dimmer shall contain circuitry to control light emitting diode (LED) lamps.

2. Electronic Low Voltage Transformer
   a. No flicker or interaction shall occur at any point in the dimming range.
   b. For integral dimming, an interface shall be required.

3. Electronic Fluorescent Dimming Ballast
   a. Dimmer shall be rated to control ballasts for T-8, T-8 high output, T-5 and T-5 high
      output lamps as well as compact lamps. All lamps on the same circuit must have
      the same current rating (i.e., T-8), but may be different lengths (i.e., 3’ and 4’). The
      dimming performance shall be as specified in the Lighting Fixture Specifications.

4. Neon and Cold-Cathode
   a. Dimmer shall provide the ability to dim lamps down to 10% of full light output when
      used with normal (low) power factor transformers. Transformers shall be sized per
      table developed by dimming system manufacturer.

5. Non-Dim/Switched Loads
   a. Non-dim shall be rated to 16A of resistive, tungsten, induction, or capacitive loads.
      Non-dim shall incorporate an air gap relay to open circuit when load is off.

G. Dimming Panels

1. Panel shall be wall or floor mounted NEMA grade, constructed of sheet steel plates not
   less than #16 U.S gauge. Contractor shall reinforce wall as required for wall-mounted
   panels.

2. Panel shall be completely pre-wired by the manufacturer. The contractor shall be
   required to provide input feed wiring, load wiring, and control wiring. No other wiring or
   assembly by the contractor shall be permitted.

3. Unless otherwise indicated, panels shall contain branch circuit protection for each
   dimming module. Branch circuit breakers shall have the following performance
   characteristics:
      a. Be U.L listed under U.L 489 as molded case circuit breaker for use on lighting
         circuits.
      b. Contain a visual trip indicator and shall be rated at 10,000 AIC (120V) or 14,000
         AIC (277V), unless otherwise noted.
      c. Be thermal-magnetic in construction for both overload and dead short protection.
         The use of fully magnetic breakers shall not be acceptable, even when used in
         conjunction with individual dimmer thermal cutouts.
      d. Be switched duty (SWD) rated so that the loads can be switched off via the
         breaker.

4. Panel shall be shipped with each dimmer in a BYPASS position via a jumper bar inserted
   between the input and load terminals. These jumpers shall carry the complete load
   current and shall be reusable at any time.

5. Panels shall be cooled via free-convection, unaided by fans, and capable of continuous
   operation to all of these Specifications within an ambient temperature range of 0°C (32°F)
   to 40°C (104°F).

6. Panel shall provide capability to electronically assign each circuit any zone in the
   dimming system. Panels using mechanical switches, rewiring, or EPROMS shall not be
   acceptable.
7. Multiple panels shall be capable of operating in one system, up to a maximum of 32 panels and 768 dimmers. Panels shall have the ability to control individual circuits without controls.

8. For panels fed with normal/emergency feeder, panel shall include electronics to bring all circuits to full on condition upon loss of normal power and subsequent presence of emergency power. Electronics shall switch both the intensity signal and the on/off signal of each dimmer connected to an emergency circuit between the local and a full-on constant drive supply. This type of emergency may be used with either a normal/emergency generator or a constant hot secondary utility feed where the emergency transfer occurs on the line side (upstream) of the dimming panel and requires only a single normal/emergency feeder.

9. Panels shall have the following additional characteristics:
   a. Be designed to prevent any foreign objects from coming into contact with any part of the panel which would be at an elevated temperature, such as the dimmer extrusions or heat fins.
   b. Be designed to provide airflow across the heat sink areas and through the dimmer chassis. Panel sections which provide airflow only across heat sinks shall not be mounted one above another in order to allow for adequate heat dissipation.

H. Dimming Modules

1. One type of modular dimming card shall be used for all sources. Systems requiring different types of modules or modular dimming cards shall not be acceptable.

2. A positive air gap relay shall be employed with each dimmer to ensure that the load circuits are open when the “off” function is selected at a control station. These relays need not be integral to the dimming module but must be integral to the dimming panel. Lighting control manufacturer shall provide necessary control interface(s) as part of the control system.

3. All dimmers shall be voltage regulated so that a nominal change in the voltage shall not cause a perceptible change in output voltage.

4. The silicon thyristors used to control the power furnished to the loads shall be both designed and tested to withstand surges, without impairment to performance, of 6000VA, 3000A (equivalent to near lightning strike) as specified by ANSI/IEEE std. C62.41. Upon request, the manufacturer shall provide a means to demonstrate conformance to this specification using the appropriate surge-generation equipment.

5. Under full-load conditions in a 40°C environment, all silicon thyristors shall operate at a minimum 20°C safely margin below the component temperature rating.

6. Filtering shall be provided in each circuit so that the current rise time shall be at least 400 µsec at 50% rated dimmer capacity as measured from 10-90% of the load current waveform at a 90° conduction angle, and at no point rise faster than 30mA/µsec. Manufacturers should note that additional filters may be required to meet this specification. These filters need not be integral to the dimming module, but must be integral to the dimming cabinet.

7. Dimmer output voltage shall be a minimum 95% of input voltage at maximum intensity setting.

8. Minimum and maximum light levels shall be user adjustable for each dimmer.

I. Integral Dimming

1. Preset dimming controls shall be capable of operating at rated capacity without adversely affecting design lifetime.

2. Preset dimming controls shall mount individually in standard 2, 3, or 4-gang concrete U.S wall boxes.

3. Preset dimming controls shall operate in an ambient temperature range of 0°C (32°F) to 40°C (104°F).
4. Preset dimming controls shall incorporate an airgap switch, which shall be accessible without removing faceplate. The airgap switch shall be capable of meeting applicable requirements of UL 20 for airgap switches in incandescent dimmers.

5. Preset dimming controls shall meet IEC 801-2, tested to withstand 15kV electrostatic discharge without damage or loss of memory.

6. Preset dimming controls shall meet ANSI/IEEE Std. C62.41-1980, tested to withstand voltage surges of up to 6000V and current surges up to 200A without damage.

7. Preset dimming controls shall meet the UL 20 limited short circuit test requirement for snap switches.

8. Preset dimming controls shall be voltage regulated.

9. Preset dimming controls shall utilize an LC filtering network to minimize interference with properly installed radio, audio, and video equipment.

10. Minimum light levels shall be user adjustable in order to compensate for different sources and loading.

11. Separate power booster/interface(s) shall increase dimmer capacity. Capacity shall range from 1000W/VA to 30,000W/VA. Quantities and size of each type of power booster shall be provided to control each type of load shown on the load schedule and/or the drawings.

J. Wall Box Dimmers

1. All devices shall be UL listed specifically for the required loads (i.e., incandescent, fluorescent, low voltage, electronic low voltage). Manufacturer shall provide file card upon request. Universal dimmers shall not be acceptable.

2. Manufacturer shall maintain ISO 9001 certification. Provide a copy of the certificate as part of the submittal.

3. All dimmers and switches shall incorporate an air gap which shall be accessible without removing the faceplate. The air gap switch shall be capable of meeting all applicable requirements of UL 20 and UL 1472 for air gap switches in incandescent dimmers.

4. All dimmers and switches shall provide power failure memory. Should power be interrupted and subsequently returned, the lights will come back on to the same levels set prior to the power interruption. Restoration to some other default level is not acceptable.

5. Dimmers and switches shall meet ANSI/IEEE Std.C62.41-1980, tested to withstand voltage surges of up to 6000V and current surges of up to 200A without damage.

6. Dimmers and switches shall meet the UL 20 and UL 1472 limited short circuit test requirement for snap switches.

7. Dimmer control shall be linear slide. Dimmer shall provide a smooth and continuous Square Law dimming curve.

8. Dimmer shall be voltage regulated so that +10% variation in line voltage shall cause not more than a +5% variation in load voltage when dimmer is operating at 40V (5% light output).

9. Dimmers shall utilize a LC filtering network to minimize interference with properly installed radio, audio, and video equipment.

10. Dimmer control slider shall be captured.

11. Faceplate shall snap on to device with no visible means of attachment. Heat-fins shall not be visible on front of device. At locations with multiple devices, one seamless, multi-gang faceplate shall be provided. Contractor is responsible for coordination of proper back box size and faceplate type.

K. Four Scene Preset Control

1. Controls shall provide access to 4 preset lighting scenes and off for up to 8 control zones. Control shall be capable of storing an additional 12 preset lighting scenes. Scenes shall be changeable as required. Up to 8 controls may be tied together for more than 8 zones. Controls shall incorporate built-in wide angle infrared receiver, providing control via a separate a separate infrared wireless remote control transmitter from up to 50 feet away. Preset shall be set via easy-to-use raise/lower switches, one raise and lower switch per
zone. The intensity for each zone shall be indicated via an illuminated bargraph. Programming of preset scenes shall be accomplished without the use of an ENTER or STORE button. One or more zones may be temporarily overridden without altering the scene values which are stored in memory. Lighting levels shall fade smoothly between scenes at time intervals of 0-59 seconds or 1 to 60 minutes. The fade time shall be separately selectable for each scene. Additionally, control shall provide power failure memory for ten years.

2. Manufacturer shall maintain ISO 9001 certification. Provide a copy of the certificate as part of the submittal.

L. Accessory Control Options

Provide the following controls for use with the preset control(s) as shown on the drawings and/or described in any lighting control charts:

1. Two Scene Entrance Control(s) shall be capable of recalling Scene One plus Off, Scenes 7 and 8, or Scenes 13 and 14. Also can be used as raise/lower partition control and Lockout. All above based on dipswitch settings.

2. Four Scene Control(s) shall be capable of recalling any one of four scenes, master raise/lower, and Off. Control shall provide access to up to 16 scenes.

3. Fine Tuning Control(s) shall allow the temporary override of a particular zone or zones from the preset light level.

4. Infrared Wireless Transmitter(s) shall be capable of recalling any one of four preset scenes and Off. In addition, a master raise/lower shall be provided. The transmitter shall be manufactured by the dimming system manufacturer. The range of the transmitter to any single receiver shall be at least 50 feet. Wall receiver shall incorporate buttons for four scene select, master raise/lower, and off. Ceiling receiver shall provide 360° view and an integral LED to provide feedback of proper infrared signal.

5. Special Function Control(s) shall provide the following functions:
   a. Sequencing shall allow the user to set up and operate a sequence of 4, 12, or 60 steps. A sequence shall be defined as a series of steps, while a step shall be defined as the recall of a scene. Each step interval is adjustable from 1 second to 60 minutes.
   b. Zone lockout shall allow temporary changes without altering light levels preset for each scene.
   c. Scene lockout shall lockout the control, maintaining current scene and disabling all buttons on the preset dimming controls.
   d. Fade override shall set all fade times to zero.

6. Partition Control(s) shall provide two or four buttons for operating multiple preset units independently or in combination. Each button shall have a corresponding LED to indicate status of a specific partition “door.”

7. Photocell Interface Control(s) shall provide scene selection via daylight photosensor.

8. Equipment Interface(s) shall allow access to preset dimming control(s) via one of the following methods:
   a. Isolated momentary/maintained dry contact closures. Where indicated on the drawings, each interface shall provide isolated maintained contact closures rated at 200mA at 30VDC for pilot light status feedback.
   b. For use with four scene preset control, RS232 serial communication.
   c. For use with four scene preset control, astronomic time clock with 60 events/day and 4 schedules.
   d. For use with multiple area-centralized control, DMX512 interface with control of 32 continuous dimming zones via external DMX512 device.

M. Wiring of lighting controls shall comply with all applicable Sections of these Specifications, as well as manufacturer’s specifications and local, state and/or national building, electrical and energy codes and regulations.
N. Equipment shall not use analog technology for communication.

O. Equipment shall be manufactured using surface mount technology.

P. Provide all hardware and software as needed to interface with the audio/video control system. Coordinate all requirements with Division 27.

PART 3 - EXECUTION

3.1 LOCATION

A. Locations of lighting controls are shown diagrammatically. Verify exact location and spacing with Plans, Sections and other reference data before ordering of lighting controls and during installation.

B. Notify Architect about field conditions at variance with Contract Documents before commencing installation.

C. Coordinate space conditions with other trades before ordering of lighting controls.

3.2 INSTALLATION

A. Wiring from dimming panel to preset dimming control and accessory controls shall be low voltage Class 2 wiring. All lighting control wiring shall be in an approved raceway specified in Section 26 05 33.

B. Provide accessories as required for construction type indicated on Finish Schedule. Lighting control catalog numbers do not necessarily denote specific mounting accessories for type of wall or surface in which a lighting control may be installed.

C. Provide adequate and sturdy support for each lighting control component. Contractor shall be responsible for verifying weight and mounting method of all lighting controls and furnishing and installing suitable supports. Lighting control mounting assemblies shall comply with all local codes and regulations.

D. Contractor shall be responsible for mounting the lighting controls at the proper depth, and for coordinating the cutout size and shape in wall to ensure that the faceplate covers the cutout entirely. Refer to drawings for location and mounting height of controls.

E. Install lighting controls with vent holes free of air-blocking obstacles.

F. Support elements shall not be mounted to or in contact with ducts or pipes.

G. Mask the lighting controls as necessary to protect the controls during construction.

H. At the completion of construction, clean the face plates and exposed surfaces of all lighting controls, so as to render them free of any material, substance or film foreign to the lighting control. Use soft, non-abrasive cloth and a cleaning solution recommended by the lighting control manufacturer. If the lighting controls are deemed dirty by the Architect at the completion of the project, the Contractor shall clean them at no additional cost to the Owner. Lighting control components whose finishes are damaged shall be replaced at no cost to the Owner.

I. Contractor shall furnish all equipment, labor and materials for the proper installation and system setup of all lighting controls and components as shown on drawings and as specified. System
setup includes defining each dimmer’s load type, assigning each load to a zone, and setting the control functions. System setup shall take place before building is turned over to Owner, after regular working hours where required.

3.3 **FIELD SUPPORT**

A. Upon completion of installation, the Manufacturer shall provide a qualified field technician to make one (1) visit to the project site to assist the Contractor in commissioning the control system. Manufacturer to be capable of providing on-site service support within 24 hours anywhere in the continental U.S.A., and within five business days anywhere in the world, except where special visas are required.

B. A local factory-trained technician within 50 miles of the project is required. Spare parts should be stocked locally.

END OF SECTION
SECTION 26 09 43

NETWORK LIGHTING CONTROL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including CM/GC Agreement and Division-1 Specification sections apply to work of this section.

B. Division-26 Basic Electrical Materials and Methods sections apply to work specified in this section.

C. Refer to lighting control matrix on drawings for operational intent.

1.2 SUMMARY

A. Section covers all system components including Energy Control Units, I/O Modules, Dimming Electronic Ballasts, Occupancy Sensors, Photo Sensors, Wall Controllers (“PCH”), Relay Control Panels, Communication Wiring, and energy and lighting control software.

1.3 SYSTEM DESCRIPTION

A. Performance Requirements: Provide all System components that have been manufactured, assembled, and installed to maintain performance criteria stated by manufacturer without defects, damage, or failure.

B. Performance Testing Requirements

1. Manufacturer shall 100% test all equipment prior to shipment. Sample testing is not acceptable.

C. Code Requirements

1. All System components shall be UL listed and CSA/cUL certified, where applicable.
2. All System components shall be FCC compliant, where applicable.
3. All System components shall be installed in compliance with national electrical codes, where applicable.
4. Building Codes: All units shall be installed in compliance with applicable, local building codes.

1.4 SUBMITTALS

A. Submittal documentation shall be furnished by the manufacturer for approval by the Engineer and must be approved in writing prior to shipment of any equipment from the manufacturer. It shall consist of:

B. Product Data: The manufacturer shall submit in a bill of material form an itemized list of all materials being supplied to meet the specifications.

C. Shop Drawings: Manufacturer shall submit dimensional drawings of all equipment.

D. Riser Diagram: Manufacturer shall submit a line diagram of the system configurations in sufficient detail to show the relative placement of all equipment and interconnection with equipment supplied by other manufacturers.
E. Wiring Diagrams: Manufacturer shall submit typical wiring diagrams for all components. Detailed interconnection diagrams are required only if proper interwiring of components is not clearly indicated on typical wiring diagrams.

F. Product Overview: Manufacturer shall submit data sheets on all components of the system. These shall describe all hardware and software items provided. A detailed line by line specification compliance shall also be included. The software shall identify the process for programming repeating time schedules.

G. Copies: Manufacturer shall provide the quantity of submittals as required by Division 1, “Submittals”.

H. Maintenance Manuals: Furnish maintenance manuals which contain equipment cuts, operating instructions, troubleshooting procedures, and spare parts list for equipment. Ensure manual includes operating instructions in addition to instructions for maintenance of the system’s software package.

I. Graphic Screens: Manufacturer shall submit graphic screens required in a two step approval process. The initial step shall provide conceptual screens showing how the system will operate. This is required prior to manufacture of the hardware. A second submittal shall be provided at time of commissioning to show fixed screen layouts incorporating “wired” conditions.

1.5 QUALITY ASSURANCE

A. Manufacturer’s Qualifications: The basis of design is Encelium Technology series with plan view graphic screens and control. Similar systems from other manufacturers listed below that meet the functional and performance requirements listed herein will be considered. A detailed line-by-line compliance comparison shall be submitted for the Engineer’s review of any alternate system. It is the sole responsibility of the Electrical Contractor to ensure that all equipment meets the specifications.

B. Installer Qualifications: Installer shall be one who is experienced in performing the work of this section, and who has specialized in installation of work similar to that required for this project.

C. Source Limitations: No sourcing limitations shall be imposed when selected from Acceptable Manufacturers except where otherwise specified in this document.

D. Manufacturer Requirements: The manufacturer shall be experienced in the manufacture of commercial lighting controls and shall provide phone support by qualified applications engineers.

E. ISO Certification: Manufacturer shall be ISO-9000 certified.

F. Codes and Standards:
   1. Electrical Code Compliance: Comply with applicable local electrical code requirements of the authority having jurisdiction and NEC as applicable to construction, installation of lighting control equipment.
   2. UL Compliance: Comply with applicable requirements of UL standard 486A, “Wire Connectors and Soldering Lugs for Use with Copper Conductors”. Provide lighting control equipment and components which are UL-listed and labeled. Any custom cabinets that may be required shall be assembled by a U.L. listed panel shop that is approved for building industrial panels. Each panel shall bear a U.L. label detailing all requirements for industrial panel fabrication.
   3. NEMA Compliance: Comply with applicable requirements of NEMA’s Stds Pub No. 250, “Enclosures for Electrical Equipment (1000-Volts Maximum)”.
   4. All lighting control equipment shall be in compliance with FCC Emission Standards specified in Part 15 Subpart J for Class A applications.
1.6 CUSTOMER SUPPORT SERVICES

A. Commissioning: The manufacturer shall supply factory trained representatives to commission the lighting control system. They shall verify that the contractor has properly installed and interconnected all supplied components. They shall start up all equipment and demonstrate that it meets the requirements of this specification.

B. Training: As part of the commissioning procedures, the manufacturer shall train the owner’s representatives in the operation of the system.

C. Technical Support: The manufacturer shall supply telephone support at no additional cost to the owner for the duration of the warranty period.

D. Replacement components: The manufacturer shall be able to ship replacement parts within 24 hours for any component that fails during the warranty period.

E. Extended Service Coverage: Maintenance agreements shall be available from the manufacturer to provide service for the system both during and after the warranty period.

1.7 WARRANTY

A. Installation Warranty: A written warranty shall be supplied by the installing contractor agreeing to provide the labor and materials to replace any portion of the lighting control system equipment or wiring that fails due to materials or workmanship for a period of 2 years after substantial completion.

B. Manufacturer’s Warranty: A written warranty shall be supplied by the manufacturer agreeing to replace any equipment that fails due to materials or workmanship for a period of twelve months.

C. Warranty Commencement: Warranty shall begin at the point of substantial completion of the system, which is defined as the date when commissioning and owner training has been completed and the Owner obtains beneficial use of the system.

1.8 DELIVERY, STORAGE AND HANDLING

A. Deliver lighting control equipment and components in factory-fabricated type containers or wrappings, which properly protect equipment from damage.

B. Store lighting control equipment in original packaging and protect from weather and construction traffic. Wherever possible, store indoors; where necessary to store outdoors, store above grade and enclose with watertight wrapping.

C. Handle lighting control equipment carefully to prevent physical damage to equipment and components. Do not install damaged equipment; remove from site and replace damaged equipment with new.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Controls: Encelium Technologies Inc. – Basis of Design.


2.2 SYSTEM REQUIREMENTS

A. Lighting Control Software: The System shall offer two, separate levels of PC interface: (1) personal lighting control for the average building occupant to control and adjust basic lighting functions in their workspace, and (2) central energy control for the lighting administrator to perform energy management, configuration maintenance, monitoring operations, and providing support to building occupants.

1. GUI: Shall provide a Windows graphical user interface.
2. Central Control: Energy Control Software interface shall provide current status and enable configuration of all System zones including selected individual fixture availability, current light level, maximum light level, on/off status, occupancy status, emergency mode status.
3. Reports: Energy performance reports shall be printable in a printer friendly format and downloadable for use in spreadsheet applications, etc.
4. Personal Lighting Controls: The Personal Control Software interface shall provide current status and enable each user with the ability to dim and brighten lights, and turn them on and off by individual fixture. The Software shall offer user configurable light scenes, which may be programmed and then selected via the Software. Personal lighting control shall be available in open office environments.

B. Daylight Harvesting (Light Regulation Averaging): In a photo sensor-equipped System, the Energy Control Unit shall rationalize changes to light levels when ambient (natural) light is available and shall maintain a steady light level when subjected to fluctuating ambient conditions. System shall utilize light level inputs from common and/or remote sensor locations to minimize the number of photo sensors required. The System shall operate with multiple users in harmony and not react adversely to manual override inputs. Daylight harvesting shall not impede personal lighting control and the ability to adjust light levels on a per fixture basis.

C. Time Clock Scheduling: The System shall be programmable for scheduling lights on or off via the Energy Control Software interface.

1. Override: Manual adjustments and occupancy sensor detection shall temporarily override off status imposed by time clock schedule.
2. Response to Power Failure: In the event of a power failure, the time clock shall execute schedules that would still be in progress had they begun during the power outage.
3. Flick warning: Five minutes prior to a scheduled lights-off event or expiry of a temporary override, the System shall provide two short light level drops as a warning to the affected occupants.

D. Load Shed Mode: An automatic load shedding mode shall be available where, when activated through the System, the control unit will reduce its output to a programmable maximum electrical demand load. The System shall not shed more load than required and load shedding priority shall be centrally configurable by light fixture. The individual user shall retain the ability to override System light levels.

E. Emergency Mode: There shall be a mode, when activated through the System, that will immediately adjust lights to full light output and retain that level until the mode is deactivated. This setting shall override all other inputs. The System shall interface with the building emergency monitoring system at a convenient point and not require multiple connections.

F. Addressing: I/O Modules shall be centrally addressable, on a per fixture basis, through the Energy Control Software. To simplify installation and maintenance, the System shall not require manual recording of addresses for commissioning or reconfiguration.
G. Programmable Task Tuning: Maximum light level programmability shall be available by individual fixture.

H. Unoccupied State: The System shall provide two states when occupancy status is vacant as per an occupancy sensor: lights turn off or lights adjust to configurable light level.

I. Occupied State: The System shall not isolate occupants by turning off lights that are still required for convenience and safety, such as a hallway path to exit the premises.

J. LAN Operations: System shall operate independently of building’s existing network infrastructure and shall not rely on tenant supplied PCs for operation. Network infrastructure shall only be utilized for Personal Control Software. Manufacturer must provide software to facilitate communications. Manufacturer shall provide connection from the PC running energy management and lighting control software to the System communication bus.

K. Firewall Security: System firewall technology shall maintain network security.

L. Low-Voltage Wiring: Wiring shall be topology independent and not require splicing or termination. Prefabricated, quick connecting wiring shall be utilized. The maximum connected length of wiring shall be no less than 425 metres (1,400 feet) per channel.

M. Lamp Burn In: The System shall not permit dimming of new lamps prior to completion of manufacturer recommended “100 hour accumulated operation at full brightness.

N. Reconfigurability: The assignment of individual fixtures to zones shall be centrally configurable by Energy Control Software such that physical rewiring will not be necessary when workspace reconfiguration is performed. Removal of covers, faceplates, ceiling tiles, etc. shall not be required.

2.3 I/O MODULE

A. General:
   1. I/O Module shall be the common interface to a ballast or sensor.
   2. Addressing: I/O Module shall be individually addressable via Energy Control Software.
   3. Response to Power Failure: In the event of a power failure, I/O Modules connected to light fixtures shall default to the “on” state at full light output.

B. Electrical Specifications
   1. Ratings: Shall be low voltage input.
   2. Voltage Compatibility: Universal voltage control capability to 347 VAC maximum.
   3. Primary Relay Rating: 347V, 0.8A/277V, 1A/240V, 1.2A/120V, 2.5A
   4. Ballast Compatibility: Suitable for use with electronic dimming ballasts using a 0 to 10 VDC dimming signal, such as Advance Mark VII 0-10V, OSRAM Sylvania Quicktronic Helios, or equivalent.
   5. Power: Shall supply 12 VDC @ 25 mA power to attached sensor.
   6. Control Signal: Shall supply 0 to 10 VDC dimming signal to attached ballast or receive control signals from attached sensor.
   7. Memory: Retains all system settings in non-volatile memory.

C. Mechanical Specifications
   1. Wiring: I/O Module shall not require wiring connections to the System apart from prefabricated, quick connecting low voltage wiring.
D. Environmental Specifications

1. Operating Temperature Range: 0°C to +40°C
2. Relative Humidity: 20% to 90% non-condensing

2.4 WALL CONTROLLERS

A. General

1. Addressing: All controllers shall be individually addressable via Energy Control Software.

B. Electrical Specifications

1. Ratings: Shall be low voltage input.

C. Mechanical Specifications

1. Operations: Localized on/off switching, dimming up/down, and programmable scene selection for dimming loads shall be provided, as required.
2. LEDs: All controllers shall feature LED’s to indicate light on and light off status, as required.

D. Environmental Specifications

1. Operating Temperature Range: 0°C to 55°C
2. Relative Humidity: 20% to 90% non-condensing

E. Aesthetic Requirements

1. Style: All controllers shall feature Decorator styling.
2. Color: All controllers shall be available in white, with an optional color insert kit for changing color without reinstalling switch.
3. Accessories: Matching wallplate shall be available.

2.5 PHOTO SENSOR

A. General

1. A sensor that measures ambient light in a finite area shall be available.
2. Specifications: The sensor shall measure light from any source in the visible spectrum within at least a 60° cone. It shall measure light between 0 and minimum 75 foot-candles.

B. Electrical:

1. Rating: Maximum 24VDC input voltage.

C. Mechanical:

1. Mounting: The sensor shall be flush mounted on or recessed inside ceiling tile.

D. Environmental Specifications

1. Operating Temperature Range: 0°C to 55°C
2. Relative Humidity: 20% to 90% non-condensing
2.6 OCCUPANCY SENSORS

A. General:
   1. Sensors using passive infrared, ultrasonic, acoustic, and multi-technology adaptive technology shall be available.
   2. Sensor timeouts shall be configurable by System software.

B. Electrical:
   1. Rating: Maximum 24 VDC input voltage, 25 mA current draw.

C. Mechanical:
   1. Mounting: Sensors for mounting on ceilings and walls, including corners, must be available.

D. Environmental:
   1. Operating Temperature Range: 0°C to 55°C
   2. Relative Humidity: 20% to 90% non-condensing

2.7 LIGHTING CONTROL PANELS

A. General
   1. Addressing: All lighting control panels shall be individually addressable via Energy Control Software.
   2. Communication: All lighting control panels shall communicate via the same prefabricated, quick connecting low voltage wiring as all other devices.
   3. Wiring: Relay control panels shall be interconnected with any other devices on the same wiring loop.
   4. Control panels shall have a minimum on 24 relays.

PART 3 - EXECUTION

3.1 PREPARATION

A. Site Verification: Verify that wiring conditions, which have been previously installed under other sections or at a previous time, are acceptable for product installation in accordance with manufacturer’s instructions.

B. Inspection: Inspect all material included in this contract prior to installation. Manufacturer shall be notified of unacceptable material prior to installation.

3.2 INSTALLATION

A. The Electrical Contractor, as part of the work of this section, shall coordinate, receive, mount, connect and place into operation all equipment. The Electrical Contractor shall furnish all conduit, wire, connectors, hardware and other incidental items necessary for properly functioning lighting control as described herein and shown on the plans. The Electrical
Contractor shall maintain performance criteria stated by manufacturer without defects, damage or failure.

1. **Compliance:** Contractor shall comply with manufacturer’s product data, including shop drawings, technical bulletins, product catalog installation instructions and product carton instructions for installation.

2. **Power:** The contractor shall test that all branch load circuits are operational before connecting loads to sensor system load terminals, and then de-energize all circuits before installation.

3. **Related Product Installation:** Refer to other sections listed in Related Sections for related products’ installation.

### 3.3 LIGHTING CONTROL ZONES

A. Lighting control zones and time functions shall be coordinated with design team and owner prior to installation. Refer to control zones below for additional information.

B. **Private Offices:**
   1. **Exterior Offices:** Daylight harvesting, ceiling mounted photo sensor and occupancy sensor with low voltage override switch control. Manual on/auto off control
   2. **Interior Offices:** Ceiling mounted occupancy sensor with low voltage override switch. Manual on/auto off control

C. **Laboratories:**
   1. **Open Labs Linear Indirect:** The following controls are per fixture row. Ceiling mounted occupancy sensor, integrated to linear indirect, task lights and pendant. Ceiling mounted photo cell for daylight harvesting as indicated on drawings. Egress lights activated with all associated entry alcove and open lab occupancy sensors.
   2. **Interior Procedure Rooms:** Ceiling mounted occupancy sensor with low voltage override switch. Manual on/auto off control.
   3. **Graduate Offices:** Ceiling mounted occupancy sensor with low voltage override switch. Manual on/auto off control.

D. **Restrooms:** Ceiling mounted occupancy sensor.

E. **Corridors:** Time clock controls 6:00am on/7:00pm off with occupancy sensor control for after hours. Egress lights are not controlled used as night lights.

F. **Collaboration Areas:** Time clock controls, 6:00am on/7:00pm off with ceiling mounted occupancy sensor control after hours. Type L4 fixtures with dimmer switch control. Type F14 wall wash, local switch control per row.

G. **Conference Rooms:** Ceiling mounted occupancy sensor with local dimming, 2 dimming zones per conference room.

H. **Administration Area:** Ceiling mounted occupancy sensor with local switching.

I. **Shell Spaces:** Ceiling mounted occupancy sensors for automatic control. Egress lights are not controlled used as night lights.

J. **Break Rooms:** Ceiling mounted occupancy sensors for automatic controls.
K. Animal Holding Rooms: Dual level control
   1. Time clock control, half level 6:00am on/6:00pm off.
   2. Manual override full on during timed on cycle only. Override shall time out after 15
      minutes.
   3. Manual override red lamp on during timed off cycle only. Override shall time out after 15
      minutes.

L. Auditorium / Large Classrooms: Dimming system with time clock controls for automatic on/off. Refer to dimming panels for control zones.

M. Service Rooms (Electrical / Telecom / Mechanical Rooms / etc.): Manual line voltage control.

N. Site / Façade / Parking Lot:
   1. Photocell On, time clock off.
   2. Parking Lot: Photo cell on/off. Time clock will uniformly reduce lighting level by half.

3.4 TESTING
A. Upon completion of all line, load and interconnection wiring, and after all fixtures are installed
and lamped, a qualified factory representative shall completely configure and test the System.

B. At the time of checkout and testing, the Owner’s representative shall be thoroughly instructed in
the proper operation of the system.

3.5 PROTECTION
A. Contractor shall protect installed product and finished surfaces from damage during all phases
of installation including preparation, testing and cleanup.

3.6 GROUNDING
A. Provide equipment grounding connections for lighting control equipment. Tighten connectors to
comply with tightening torques specified in UL Std 486A to assure permanent and effective
grounding.

3.7 FIELD QUALITY CONTROL
A. Manufacturers’ Field Services. Arrange and pay for the services of factory-authorized service
representatives to commission, test and program the lighting control system.

B. Reports. Prepare written reports of texts and observations. Report defective materials and
unsatisfactory test results. Record repairs and adjustments made.

C. Test Labeling. Upon satisfactory completion of tests and inspections, apply a label to tested
panels indicating test results, date and testing organization and person.

3.8 CLEANING
A. Cleaning. The contractor shall remove all paint spatters and other spots, dirt and debris from
the equipment. Clean equipment and devices internally and externally using methods and
materials recommended by the manufacturers.
3.9 COMMISSIONING

A. Operational Test. This contractor shall provide a complete set of “as wired” drawings of the lighting control system to the owner. These drawings shall be prepared and verified prior to commissioning of the system. Any extra expenses incurred in commissioning the system due to inaccurate or incomplete wiring shall be borne by the electrical contractor.

B. Training. Arrange and pay for the services of factory-authorized service technicians to demonstrate the lighting control system and train Owner’s maintenance personnel. Provide 2 weeks notice of training dates. A minimum of 80 hours of training shall be provided after completion of system. Anticipate three separate trips will be needed for customer/user training.

C. Programming. Arrange and pay for the services of factory authorized service technicians to install an initial lighting control program into the system. Coordinate schedules with the Owner so that a complete schedule is available at the time of commissioning. This Contractor shall be responsible for schedule updates until system is turned over to Owner.

D. Graphic Screens. The Electrical Contractor shall provide the manufacturer with reflected ceiling plans for all areas being controlled by the lighting control system. These shall reflect “as wired” conditions and will be the basis for the detail screens for the graphic computer screens. It is this Contractor’s responsibility to insure their accuracy.

END OF SECTION
SECTION 26 22 13
LOW VOLTAGE DISTRIBUTION TRANSFORMERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to work of this section.

B. Requirements of the following Division 26 Sections apply to this section.
   1. “Electrical Requirements.”

1.2 SUMMARY

A. This section includes general purpose and specialty dry type transformer with winding rated 600V or less, with capacities up to 1000 KVA.

B. Related Sections: The following Division 26 Sections contain requirements that relate to this section:
   1. “Electrical Identification” for signs associated with transformer installations.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections:
   1. Product data for each transformer, including dimensional plans view electrical rooms, sections, and elevations showing minimum clearances, installed devices, and material lists.
   2. Wiring diagrams from manufacturer differentiating between manufacturer-installed and field-installed wiring.
   3. Product certificates, signed by manufacturer of transformers certifying that their products comply with the specified requirements.
   4. Product Test Reports: Certified copies of manufacturer’s design and routine factory tests required by the referenced standards.

B. Provide the additional LEED submittal information:
   1. EA Credit 1: Optimize Energy Performance. Provide baseline and proposed performance as defined in LEED – NC 2.2 submittal template for this credit.
   2. EA Credit 3: Enhanced Commissioning. Provide systems manual as required by this credit for use by the commissioning agent.

1.4 QUALITY ASSURANCE

A. Manufacturer’s Qualifications: A firm member of NEMA who is regularly engaged in manufacturing components that comply with the requirements of these Specifications and that have been used on at least five projects of similar size and scope as this Project.
B. Field Testing Organization Qualifications: To qualify for acceptance, an independent testing organization must demonstrate, based on evaluation of organization-submitted criteria conforming to ASTM E 699, that it has the experience and capability to conduct satisfactorily the testing indicated.

C. Electrical Component Standard: Components and installation shall comply with NFPA 70 “National Electrical Code.”


E. DOE CSL3 standards for energy efficiency.

F. UL Listing and Labeling: Items provided under this section shall be listed and labeled by UL.

G. Nationally Recognized Testing Laboratory Compliance (NRTL): Items provided under this section shall be NRTL listed and labeled. The term “NRTL” shall be as defined in OSHA Regulation 1910.7.

PART 2 - PRODUCTS

2.1 TRANSFORMERS, GENERAL

A. Transformers: Factory assembled and tested, air cooled units of types specified, having characteristics and ratings as indicated on drawings. Units shall be designed for 60 Hz service.

B. Cores: Grain oriented, non-aging silicon steel.

C. Coils: Continuous windings without splices except for taps.

D. Internal Coil Connections: Brazed or pressure type.

E. Wiring compartment and termination shall be accessible by removing enclosure front panels.

F. The use of fans to obtain rated KVA or efficiency rating shall not be permitted for all transformer types.

2.2 GENERAL PURPOSE, DRY-TYPE TRANSFORMERS

A. Comply with NEMA Standard ST 20 “Dry-Type” Transformers for General Applications.

B. Windings: 2 winding type. Three phase transformers shall use one coil per phase in primary and secondary.

C. Provide copper windings.

D. Sound Level: Sound levels shall not exceed the following: 150 KVA and below, 50 db; above 150 KVA, 60 db.

E. Transformers shall have the following features and ratings:

1. Enclosure: Indoor, ventilated, drip proof in electric rooms.
2. Enclosure: Outdoor, ventilated raintight, NEMA 3R.
3. Insulation Class: 185°C class for 15 KVA transformers or smaller; 220°C class for transformers larger than 15 KVA.

4. Insulation Temperature Rise: 80°C maximum rise above 40°C, for 220°C class insulation; 80°C maximum rise for 185°C class insulation.

5. Taps: For transformer 3KVA and larger, full capacity taps in high-voltage winding as follows:
   a. 3 KVA through 15 KVA: Four 2.5% taps, two above and two below normal voltage.
   b. 15 KVA through 1000 KVA: Four 2.5% taps, two above and four below rated normal voltage.

F. Accessories: As follows:
   1. Core and coil assemblies 30 KVA and larger to be mounted on rubber vibration isolators on concrete pads.

G. Maximum no load losses shall not exceed:
   1. 15 KVA – 60W
   2. 30 KVA – 99W
   3. 45 KVA – 130W
   4. 75 KVA – 180 W
   5. 112.5 KVA – 260W
   6. 150 KVA – 330W

H. Efficiency at 1/6 loading shall meet or exceed:
   1. 15 KVA – 97.0%
   2. 30 KVA – 97.6%
   3. 45 KVA – 97.8%
   4. 75 KVA – 98.3%
   5. 112.5 KVA – 98.5%
   6. 150 KVA – 98.4%

I. Transformer shall meet or exceed DOE 10 CFR part 430 CSL 3 efficiency requirement. Tested per NEMA TP-2.
   1. 15 KVA – 97.6%
   2. 30 KVA – 98.1%
   3. 45 KVA – 98.3%
   4. 75 KVA – 98.6%
   5. 112.5 KVA – 98.8%
   6. 150 KVA – 98.9%

J. Efficiency under K-7 nonlinear load at 50% of nameplate rating:
   1. 15 KVA – 97.2%
   2. 30 KVA – 97.7%
   3. 45 KVA – 97.9%
   4. 75 KVA – 98.1%
   5. 112.5 KVA – 98.5%
   6. 150 KVA – 98.7%

K. Mounting: All transformers shall be floor mounted.
2.3 NOISE ISOLATION TRANSFORMER

A. Transformers: Factory assembled and tested, air cooled units of types specified, having characteristics and ratings as indicated on drawings. Units shall be designed for 60 Hz service.

B. Transformer core shall be constructed of high grade grain oriented silicon steel.

C. Coils shall use high grade magnet wire. Coils shall have clearly marked terminal pads attached to a rugged fiberglass termination strip. Windings shall be vacuum impregnated with nonhydroscopic thermosetting varnish for superior strength and heat transfer.

D. Transformer shall have (2) 2.5 percent above nominal and (4) 2.5 percent below nominal universal full capacity taps.

E. Insulation system shall be UL Recognized at 220 degree C and shall be capable of continuous operation at 40 degree C ambient without windings exceeding 80 degree C temperature rise. Surface temperature rise shall not exceed UL 50 degree C limit. Wiring compartment temperature rise shall not exceed UL 35 degree C limit.

F. Floor mount enclosure shall be constructed of heavy gauge steel for indoor use. Weathershield kits shall be available to modify enclosures for NEMA 3R outdoor use.

G. Wiring compartment shall be sized for aluminum cable rated 125 percent of current, using long shanked crimp type connectors. Wiring compartment shall be accessible by removing enclosure front panel.

H. Vibration from core and coil assembly shall be isolated from enclosure by neoprene vibration pads and sleeves. A flexible copper grounding strap shall connect core to enclosure. A schematic connection diagram shall be located on enclosure nameplate for quick referral.

I. A premium electrostatic shield shall be included, consisting of a full width copper sheet placed between primary and secondary windings. Effective coupling capacitance shall be thirty picofarads. Average common mode noise attenuation shall be 120 db.

J. A rugged filter shall provide an average 60 db normal mode noise attenuation.

K. Surge suppression components shall be included to eliminate low voltage spikes and surges.

2.4 K-RATED TRANSFORMERS

A. General:

1. Transformer coils shall be of the continuous wound construction and shall be impregnated with nonhygroscopic, thermosetting varnish.

2. Transformers 15 KVA and larger shall have a minimum of 6-2.5% full capacity primary taps for 480V primaries. Exact voltages and taps to be as designed on the plans or the transformer schedule.

B. Ratings:

Transformer insulation shall be a UL recognized 220ºC system. Neither the primary nor the secondary temperature shall exceed 220ºC at any point in the coils while carrying their full rating of non-sinusoidal load. The maximum temperature hot spot temperatures shall not
exceed the following values for the indicated K factors, defined as the sum of fundamental and harmonic I (pu) * h² per ANSI/IEEE C57.110-1986.

<table>
<thead>
<tr>
<th>Hot Spot Temperature</th>
<th>K Factor Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>220°C</td>
<td>4.0</td>
</tr>
<tr>
<td>185°C</td>
<td>3.2</td>
</tr>
<tr>
<td>150°C</td>
<td>2.7</td>
</tr>
</tbody>
</table>

Manufacturers rating K factors by average temperature rise alone shall not be acceptable.

C. Construction:

1. All cores to be constructed with low hysteresis and eddy current losses. The core flux density shall be well below the saturation point to prevent core overheating caused by harmonic voltage distortion. Manufacturers shall submit verification of induction levels well below the usual level for standard transformers.

2. Transformers shall be common core construction. Transformers utilizing more than one core, or Scott-T connections shall not be acceptable.

3. The transformer secondary neutral terminal shall be sized for 200% of the secondary phase current.

4. The transformer enclosures shall be ventilated and be fabricated of heavy gauge, sheet steel construction. The entire enclosure shall be finished utilizing a continuous process consisting of degreasing, cleaning and phosphatizing, followed by electrostatic deposition of a polymer polyester powder coating and baking cycle to provide uniform coating of all edges and surfaces. The coating shall be UL recognized for outdoor use. The coating color shall be ANSI 49.

5. The maximum temperature of the top of the enclosure shall not exceed 50°C rise above 40°C ambient.

6. Transformers shall be supplied with a quality, full width electrostatic shield resulting in a maximum effective coupling capacitance between primary and secondary of 33 picofarads. With transformers connected under normal, loaded operating conditions, the attenuation of line noise and transients shall equal or exceed the following limits:

   **Common Mode:**
   
<table>
<thead>
<tr>
<th>Frequency Range</th>
<th>Attenuation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 1.5Hz</td>
<td>120db</td>
</tr>
<tr>
<td>1.5 to 10 kHz</td>
<td>90db</td>
</tr>
<tr>
<td>10 to 100 kHz</td>
<td>65db</td>
</tr>
<tr>
<td>100kHz to 40db</td>
<td></td>
</tr>
</tbody>
</table>

   **Traverse Mode:**
   
<table>
<thead>
<tr>
<th>Frequency Range</th>
<th>Attenuation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5 to 10kHz</td>
<td>52db</td>
</tr>
<tr>
<td>10 to 100kHz</td>
<td>30db</td>
</tr>
</tbody>
</table>

7. Sound levels shall be warranted by the manufacturer not to exceed the following:

<table>
<thead>
<tr>
<th>Power Range</th>
<th>Sound Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 to 50kVA</td>
<td>45db</td>
</tr>
<tr>
<td>51 to 150kVA</td>
<td>50db</td>
</tr>
</tbody>
</table>

PART 3 - EXECUTION

3.1 INSTALLATION

A. Arrange equipment to provide adequate spacing for cooling air circulation.
B. Identify transformers in accordance with Division 26 Section “Electrical Identification.”

C. Tighten electrical connectors and terminals in accordance with manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.2 EQUIPMENT BASES

A. All transformers shall be floor mounted.

B. Construct concrete equipment pads as follows:
   1. Coordinate size of equipment bases with actual unit sizes provided. Construct base 4 inches high and 2 inches larger in all directions than the overall dimensions of the supported unit.
   2. Form concrete pads with framing lumber with form release compounds. Chamfer top edge and corners of pad.
   3. Install reinforcing bars, tied to frame, and place anchor bolts and sleeves to facilitate securing units.
   4. Place concrete and allow to cure before installation of units. Use Portland Cement conforming to ASTM C 150, 4000 psi compressive strength, and normal weight aggregate.

3.3 GROUNDING

A. Ground transformers and tighten connections to comply with torque tightening requirements specified in UL Standard 486A.

3.4 FIELD QUALITY CONTROL

A. Inspect for physical damage, broken insulation, tightness of connections, defective wiring, and general condition.

B. Thoroughly clean unit prior to making any tests.

C. Perform insulation-resistance test. Calculate dielectric absorption ratio and polarization index. Make measurements from winding-to-winding and winding-to-ground. Test voltages and minimum resistance shall be in accordance with Table below:

<table>
<thead>
<tr>
<th>Minimum dc Test Voltage</th>
<th>Recommended Minimum Insulation Resistance in Megohms</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000 volts</td>
<td>500</td>
</tr>
</tbody>
</table>

D. Verify taps and connect transformer to desired tap, if applicable.

E. Energize primary winding with system voltage. Measure secondary voltage with the secondary load disconnected. Record results.

3.5 ADJUSTING AND CLEANING

A. Upon completion of installation, inspect interiors and exteriors of accessible components. Remove paint splatters and other spots, dirt and construction debris. Touch up scratches and mars on finish to match original finish.

B. Adjust transformer taps to provide optimum voltage conditions at utilization equipment.
3.6 PROTECTION

A. Temporary Heating: Apply temporary heat in accordance with manufacturer’s recommendations within enclosure of each transformer throughout periods during which equipment is not in a space that is continuously under normal control of temperature and humidity.

END OF SECTION
SECTION 26 24 16
PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

B. Division 26 Basic Electrical Material and Methods sections apply to work specified in this section.

1.2 SUMMARY

A. Provide all panelboards and enclosure work, including cabinets and cutout boxes, as indicated by drawings and schedules, and a specified herein.

B. Types of panelboards, and enclosures required for the project include the following:
   1. Power-distribution panelboards.
   2. Lighting and appliance panelboards.

C. All panelboards, switchgears, disconnect switches, starters, etc., shall be fabricated by the same manufacturer throughout the entire project.

D. Wires/cables, bus-way, electrical boxes and fittings, and raceways required in conjunction with the installation of panelboards, and enclosures are specified in other Division 26 sections.

1.3 SUBMITTALS

A. Product Data: Submit manufacturer’s data on panelboards, and enclosures.

B. Wiring Diagrams: Submit wiring diagrams for panelboards showing connections to electrical power feeders and distribution branches.

C. Submit electrical room plan view drawings at ¼” scale showing all equipment, panelboards, disconnects and ratings, buss work, conduit areas, dimensions and mounting of equipment supplied.

D. The equipment product data, electrical room layouts and short-circuit study shall be submitted together in order to provide proper evaluation.

E. Submittals shall be in accordance with specification section 26 05 02.

1.4 QUALITY ASSURANCE

A. Manufacturer’s Qualifications: The manufacturer of this equipment shall be regularly engaged in manufacture of panelboards and enclosures, of types, sizes, and ratings required and have produced similar electrical equipment, for a minimum period of five (5) years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.
B. Codes and Standards

1. Electrical Code Compliance: Comply with applicable local code requirements of the authority having jurisdiction and NEC Article 384 as applicable to installation, and construction of electrical panelboards and enclosures.

2. UL Compliance: Comply with applicable requirements of UL 67, “Electric Panelboards”, and UL’s 50, 869, 486A, 486B, 891, and 1053 pertaining to panelboards, accessories and enclosures. Provide panelboard units which are UL-listed and labeled.

3. Special-Use Markings: Provide panelboards, constructed for special-use, with appropriate UL markings which indicated that they are suitable for special type of use/application.


1.5 DELIVERY, STORAGE, AND HANDLING

A. Store panelboards in clean dry space. Protect units from dirt, fumes, water, construction debris and traffic; where necessary to store outdoors, store electrical components above grade and enclose with watertight wrapping.

B. Handle panelboards carefully to prevent internal components damage, breakage, denting, and scoring enclosure finish. Do not install damaged components; replace and return damaged units to equipment manufacturer.

1.6 SEQUENCING AND SCHEDULING

A. Coordinate installation of panelboards and enclosures with installation of wires/cables, electrical boxes and fittings, and raceway work.

PART 2 - PRODUCTS

2.1 PANELBOARDS (800 AMPS OR LESS)

A. General: Except as otherwise indicated, provide panelboards, enclosures and ancillary components, of types, sizes, and ratings indicated on drawings, which comply with manufacturer’s standard materials; with the design and construction in accordance with published product information; equip with proper numbers of unit panelboard devices as required for complete installation.

B. Power Distribution Panelboards: Provide dead-front safety type power distribution panelboards as indicated, with panelboards switching and protective devices in quantities, ratings, types, and with arrangement shown; with anti-turn solderless pressure type main lug connectors approved for use with copper conductors. Select unit with feeders connecting at top of panel. Equip with copper buss bars with not less than 98% conductivity, and with full-sized neutral buss; provide suitable lugs on neutral bus for outgoing feeders requiring neutral connection. Provide molded-case main and branch circuit-breaker types for each circuit, with toggle handles that indicated when tripped. Where multiple-pole breakers are indicated, provide with common trip so overload on one pole will trip all poles simultaneously. Provide panelboards with bare uninsulated grounding bars suitable for bolting to enclosures. Select enclosures fabricated by same manufacturers as panelboards, which mate and match properly with panelboards. Employ bolt on breakers that are fully rated for the available short-circuit condition but of not less than 22,000 sym AIC.
C. Lighting and Appliance Panelboards: Provide dead-front safety type lighting and appliance panelboards as indicated, with switching and protective devices in quantities, ratings, types and arrangements shown. Equipped with anti-turn solderless pressure type lug connectors approved for use with copper conductors; construct unit for connecting feeders at top of panel; equip with copper buss bars, full-sized neutral bar, with bolt-in type heavy-duty, quick-make, quick-break, single-pole circuit breakers, with toggle handles that indicate when tripped. Provide suitable lugs on neutral buss for each outgoing feeder required; and provide bare uninsulated grounding bars suitable for bolting to enclosures. Select enclosures fabricated by same manufacturers as panelboards, which mate and match properly with panelboards. Employ breakers that are fully rated for the available short-circuit condition but not less than 10,000 sym AIC at 120/208 volts; and 14,000 sym AIC at 277/480 volts.

D. Panelboard Enclosures: Provide galvanized sheet steel cabinet type enclosures, in sizes and NEMA types as indicated, code-gage, minimum 16-gage thickness. Construct with multiple knockouts and wiring gutters. Provide fronts with adjustable trim clamps, and doors with flush locks and keys, all panelboard enclosures keyed alike, with concealed piano door hinges with door in door swings as indicated. Equip with interior circuit-directory frame, and card with clear plastic covering. Provide baked gray enamel finish over a rust inhibitor coating. Design enclosures for surface mounting. Provide enclosures which are fabricated by same manufacturer as panelboards, which mate and match properly with panelboards to be enclosed.

E. Molded-Case Circuit Breakers: Provide factory-assembled, molded-case circuit breakers of frame sizes, characteristics, and ratings including RMS symmetrical interrupting ratings indicated. Select breakers with permanent thermal and instantaneous magnetic trip, and ampere ratings as indicated on the drawings. Construct with overcenter, trip-free, toggle-type operating mechanisms with quick-make, quick-break action and positive handle trip indication. Construct breakers for mounting and operating in any physical position, and operating in ambient temperature of 40°C. Provide breakers with mechanical screw type removable connector lugs, AL/CU rated. The breakers for 277/480V panelboards shall be industrial grade; breakers that allow or direct particles of combustion resulting from fault conditions out of the breaker are not acceptable, they shall be contained within it’s casing. For example; GE AE series panelboards with TEY circuit breakers are not acceptable, TED breakers are acceptable.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine area and conditions under which panelboards and enclosures are to be installed, and notify Engineer in writing of conditions detrimental to proper completion of work. Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install panelboards and enclosures as indicated, in accordance with manufacturer’s written instructions, applicable requirements of NEC standards and NECA’s “Standards of Installation”, and in compliance with recognized industry practices to ensure that products fulfill requirements.

B. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturers’ published torque tightening values for equipment connectors. Where manufacturer’s torque requirements are not indicated, tighten connectors and terminals to comply with torque tightening requirements specified in UL Std 486A and B.

C. Fasten enclosures firmly to walls and structural surfaces, ensuring that they are permanently and mechanically anchored.
D. Provide properly wired electrical connections for panelboards within the enclosures.

E. Provide engraved, plastic laminate labels for all panelboards indicating name, voltage, phase, wire and short circuit rating. Refer to Section 26 05 53 for more information.

F. Provide typed panelboards circuit directory card upon completion of installation work to match as-built conditions and nomenclature indicated on engineering drawings and submit directories to the Engineer for review prior to mounting in panelboard.

G. Provide compression lugs for all panelboards larger than 400Amps. Mechanical screw lugs for panels 4000Amps and below.

3.3 GROUNDING

A. Provide equipment grounding connections as indicated herein. Tighten connection to comply with torque tightening requirements specified in UL 486A to assure permanent and effective grounds.

B. Refer to Section 26 05 26 for additional grounding requirements.

3.4 FIELD QUALITY CONTROL


A. Infrared Inspection shall be performed 6 months after Owner has moved in and is utilizing equipment.

1. The scan is to include all electrical panelboards or bussed distribution equipment.
2. All equipment should be energized at normal load levels during an event for at least 1 to 2 hours prior to being scanned.
3. Access covers are to be removed and reinstalled by the electrical Contractor for the Engineer to inspect and scan all electrical junctions, buss, and cable.
4. The IR Scan will be made using an video. The camera shall provide infrared photos clearly indicating problem areas.
5. All problem areas will be noted as to location, description, and recommended solution by providing a typed report including infrared and Polaroid pictures of all problem areas.

B. Panelboards:

1. Visual and Mechanical Inspection:
   a. Inspect for physical damage and code violations.
   b. Inspect for proper alignment, anchorage and grounding.
   c. Inspect for proper identification of protective devices and switches.
   d. Check tightness of accessible bolted buss joints.
   e. Physically test all electrical or mechanical interlocks to assure proper function.
   f. Clean interior and insulator surfaces once a month prior to job completion.
   g. Inspect for proper operation of space heaters and thermostat settings (if they exist).

2. Electrical Tests:
   a. Measure insulation resistance of each buss section phase-to-phase and phase-to-ground.
   b. Check panelboards for electrical continuity of circuits and for short circuits.
3.5 ADJUSTING AND CLEANING

A. Adjust operating mechanisms for free mechanical movement.
B. Touch-up scratched or marred surfaces to match original finishes.

3.6 DEMONSTRATION

A. Subsequent to wire and cable hook-ups, energize and demonstrate functioning in accordance with requirements. Where necessary, correct malfunctioning units, and then retest to demonstrate compliance.

END OF SECTION
SECTION 26 27 26
WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Requirements of the following Division 26 Sections apply to this section.

1.2 SUMMARY

A. This Section includes the following:

1. Receptacles
2. Ground Fault Circuit Interrupter Receptacles
3. Plugs
4. Plug Connectors
5. Snap Switches
6. Incandescent Lamp Dimmer-Switches
7. Wall Plates
8. Occupancy Sensors

B. Related Sections: The following sections contain requirements that relate to this section:

1. Division 26 Section “Motor Disconnects and Fuses” for devices other than snap switches and plug/receptacle sets used as disconnects for motors.

1.3 SUBMITTALS

A. Product data for each type of product specified.

B. Occupancy Sensors

1. Submit a lighting plan clearly marked by manufacturer identifying product type, locations, orientation and coverage for each sensor.
2. Submit any interconnection diagrams per major subsystems showing proper wiring.

1.4 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with provisions of the following codes.

1. NFPA 70 “National Electrical Code.”

B. UL and NEMA Compliance: Provide wiring devices which are listed and labeled by UL, Federal Specification and comply with applicable UL and NEMA standards.

1.5 SEQUENCE AND SCHEDULING

A. Schedule installation of finish plates after the surface upon which they are installed has received final finish.
PART 2 - PRODUCTS

2.1 WIRING DEVICES

A. General: Provide wiring devices, in types, characteristics, grades, colors, and electrical ratings for applications indicated which are UL listed and which comply with NEMA WD 1 and other applicable UL and NEMA standards.

B. Color of Devices: Color of all devices shall be coordinated with the Architect, except special purpose devices shall be black, emergency power system devices which shall be red, corrosion-resistant devices which shall be yellow, or isolated ground devices which shall be orange.

C. Receptacles: As scheduled in Table 1 in Part 3 indicated herein. Comply with UL 498 and NEMA WD 1 and WD 6.

D. Receptacles, Industrial Heavy Duty: Provide pin and sleeve design receptacles conforming to UL 498. Comply with UL 1010 where installed in hazardous locations. Provide features indicated.

E. Ground-Fault Interrupter (GFI) Receptacles: As scheduled in Table 1 in Part 3 indicated herein: Provide “terminal” or feed-through type ground-fault circuit interrupter, as indicated on drawings, with integral heavy-duty NEMA 5-20R duplex receptacles. Provide unit designed for installation in a 2-3/4-inch deep outlet box without adapter, grounding type, Class A, Group 1 per UL Standard 943.

F. Snap Switches: As scheduled in Table 2 in Part 3 indicated herein.

G. Wall Dimmer: As scheduled in Table 2 in Part 3 indicated herein.

1. Incandescent wall dimmers shall be 120 volt, solid state type with slide control handle, preset button and semi-flush mounting. Dimmers shall be sized to continuously carry the load they are connected to, the minimum size shall be 1000 watts, and shall be rated larger if indicated on the drawings or required to serve the load.

2. Dimmers indicated on the drawings to serve low voltage incandescent lamps shall be the same as specified for incandescent lamps and in addition shall be specifically rated for the low voltage transformer load. Dimmer shall be UL listed for use with low voltage fixtures.

3. Dimmers indicated to serve fluorescent lamps shall be 120v or 277v, as required for circuit served, solid state type for use with fluorescent dimming ballasts. Control shall be slide handle and dimmer shall be for semi-flush mounting.

4. All dimmers shall be of the same manufacturer. Faceplate shall be the same color as device plates specified.

H. Floor Box – Fire Rated Poke-Through

1. Refer to Technology Drawings for specifications.

I. Floor Box – Surface Mount

1. Refer to Technology Drawings for specifications.

J. Floor Box – Recessed Mount

1. Refer to Technology Drawings for specifications.
K. All exterior weatherproof receptacles located on the roof, receptacles located in elevator pits and machine rooms shall be GFI type or GFI protected and have “in use” covers.

L. All devices shall be premium specification grade.

2.2 WIRING DEVICE ACCESSORIES

A. Wall Plates: Single and combination, of types, sizes, and with ganging and cutouts as indicated. Provide metal screws for securing plates to devices with screw heads colored to match finish of plates. Provide wall plates with engraved legend where indicated on drawings. Engraving shall be done by the device manufacturer. All lettering shall be 1/8-inch high and shall be black for normal power systems and red for emergency power systems. Provide plates possessing the following additional construction features:

1. Material and Finish: 0.04 inch thick, type 302 satin finished stainless steel. Plate shall be Hubbell “S” Series or approved equal.

B. For all devices installed which are exposed to the weather, moisture or where indicated on the drawings, device plates shall be weatherproof. Device plates shall be cast type with gasketing to prevent entrance of moisture when closed.

2.3 OCCUPANCY SENSORS

A. General: Layouts shown on plan drawings are intended to show general control concepts (i.e. wall sensors, ceiling sensors, or switch sensor) for an area. The contractor shall provide sensor coverage of the entire space based on the concept shown, as well as all other devices required (power packs, control wiring, switching, etc.) for a complete and working system. Low voltage switching to allow local override of the sensors shall be provided at all entries to areas shown as controlled by ceiling or wall mounted sensors. In areas that require two or more sensors for full coverage, the sensors shall be interconnected together to provide a single switching zone for the entire space, regardless of the number of circuits.

B. Occupancy sensor shall be Watt Stopper SDRAWSEN/SCOMSEN or approved equal.

C. Wall switch sensor shall be capable of detection of occupancy up to 300 square feet and gross motion up to 1000 square feet. Wall switch sensors shall accommodate loads from 0 to 800 watts at 120 volts, 0 to 1200 watts at 277 volts and shall have 180° coverage capability. All wall switch shall utilize zero crossing circuitry, field delectable option (automatic – on to manual on).

D. Ceiling mounted sensors shall be dual technology (passive infrared and ultrasonic). The sensor shall offer day lighting foot candle adjustment control and be able to accommodate dual level lighting. Sensors shall be immune to false triggering from RFI and EMI.

E. All sensors shall utilize automatically adjustable time delay and sensitivity settings. Settings shall be located on sensor.

F. In the event of failure, a bypass override shall be provide on each sensor. When bypass is utilized, lighting shall remain on constantly or control shall diver to a wall switch until sensor is replaced. This control shall be recessed to prevent tampering.

G. All sensors shall provide an LED as a visual means of indication at all times to verify that motion is being detected during both test and normal operation.

H. Sensors shall have an internal additional isolated relay with normally open, normally closed and common outputs for use with HVAC control, data logging and other control options.
2.4 MULTI OUTLET ASSEMBLIES (MOA)

A. Aluminum dual channel, Hubbell HBLAU4800 Series or approved equal shall be a two-piece design with a base and cover. Factory assembled, with mounting hardware and instructions included. Provide fittings that match and mate with raceway.

B. Raceway base and cover shall be an extruded aluminum construction with satin anodized finish on all surfaces.

C. Extruded raceway base and cover shall be made of 6063-T5 aluminum alloy, with nominal thickness of .080”.

D. The assembled external dimensions shall be 6.0” wide by 2.25” deep with an internal cross sectional area of 11.60 square inches. Raceway base section shall be available in 12 lengths.

E. Raceway base shall have an integral extruded divider separating the 6” raceway into two equally sized channels.

F. Each raceway base channel shall accept an individual cover to form two separate partitioned compartments. Partitioned compartments shall permit both power and communications wiring in separate channels.

G. Assembly and disassembly of raceway base, cover and fittings shall require no special tools.

H. Device cover plates shall accept commercially available devices, including duplex devices, single 1.40”, 1.59” and 2.13” diameter receptacles, GFCI surge receptacles and other compatible rectangular shaped devices.

I. All power devices shall be pre-assembled in the factory. Circuiting shall be as indicated on drawings. Provide circuit labeling information for every device in raceway.

J. Communications device cover plates shall also accommodate various faceplates.

K. Accessories:
   1. Couplings for joining raceway sections.
   2. Wire clips for conductors.
   3. Blank end fittings.
   5. Device brackets for single or two gang devices.
   6. Combination receptacle and telephone outlet covers.
   7. Outlet boxes with hubs for conduit connectors.

L. All face plates shall be provided from a continuous manufactured process. Cover plates shall be oriented such that the blushed pattern is in a common direction, providing a uniformed finish. Cover plates may need to be replaced at no cost to the Owner based on the Architect’s final review if uniformity is not accomplished.

M. Provide circuit identification labels as required by Section 26 05 53.
PART 3 - EXECUTION

3.1 INSTALLATION OF WIRING DEVICES AND ACCESSORIES

A. Install wiring devices and accessories as indicated, in accordance with manufacturer’s written instructions, applicable requirements of NEC and in accordance with recognized industry practices to fulfill project requirements.

B. Coordinate with other work, including painting, electrical boxes and wiring installations, as necessary to interface installation of wiring devices with other work.

C. The mounting height of devices is indicated in the legend on the drawings. Where finished walls are exposed concrete block, brick or tile, the height shall be adjusted to allow outlet box for device to be mounted at a joint.

D. Receptacles above countertops shall be installed with major axis horizontal above the backsplash.

E. Mount all devices within outlet boxes to allow device plates to be in contact with wall on all sides. Align devices with major axis of device parallel to adjacent predominant building feature, i.e., door frames or countertops.

F. Install wall switches on the strike side of doors.

G. Install wiring devices only in electrical boxes which are clean; free from building materials, dirt, and debris.

H. Provide a current carrying conductor, neutral, equipment grounding conductor and an insulated grounding conductor to each isolated ground “IG” receptacle.

I. Install galvanized steel wall plates in unfinished spaces.

J. Install wiring devices after wiring work is completed.

K. Install wall plates after painting work is completed.

L. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer’s published torque tightening values for wiring devices. Where manufacturer’s torque requirements are not indicated, tighten connectors and terminal to comply with tightening torque requirements specified in UL Standard 486A. Use properly scaled torque indicating hand tool.

M. Provide circuit identification labels as required by Section 26 05 53.

3.2 PROTECTION

A. Protect installed components from damage. Replace damaged items prior to final acceptance.

3.3 FIELD QUALITY CONTROL

A. Testing: Prior to energizing circuits, test wiring for electrical continuity, and for short-circuits. Ensure proper polarity of connections is maintained. Subsequent to energizing test wiring devices and demonstrating compliance with requirements, operate each operable device at least six times.
B. Test ground fault interrupter operation with both local and remote fault simulations in accordance with manufacturer recommendations.

C. TABLE 1

RECEPTACLES

<table>
<thead>
<tr>
<th>Designation (1)</th>
<th>Current Rating (Amps)</th>
<th>Voltage Rating</th>
<th>Single/Duplex</th>
<th>NEMA Config.</th>
<th>Hubbell Catalog # (3)</th>
<th>Notes</th>
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</thead>
<tbody>
<tr>
<td>-</td>
<td>20</td>
<td>125</td>
<td>Duplex</td>
<td>5-20R</td>
<td>HBL5362</td>
<td>-</td>
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<td>-</td>
<td>20</td>
<td>125</td>
<td>Single</td>
<td>5-20R</td>
<td>HBL5361</td>
<td>-</td>
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<tr>
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<td>20</td>
<td>125</td>
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<td>5-20R</td>
<td>IG5362</td>
<td>Isolated Ground</td>
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<td>GF8300A/ WP26M(4)</td>
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<td>HBL8300SGA</td>
<td>Tamperproof</td>
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NOTES

1. Letter designations are used where symbols alone do not clearly designate on plans locations where specific receptacle types are used.
2. Protecting downstream receptacles on same circuit is not acceptable.
3. Refer to Section 26 05 05 for additional acceptable manufacturers. Color of device shall be verified with Architect (ivory, gray, white, etc.). All emergency receptacles shall be red.
4. Where required per NEC or local code provide ‘RW57900’ in-use water-proof cover for two-gang devices.

D. TABLE 2

SNAP SWITCHES/WALL DIMMERS

<table>
<thead>
<tr>
<th>Designation (1)</th>
<th>Typical Application</th>
<th>Load Rating</th>
<th>Voltage Rating (AC)</th>
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<td>Control Lights</td>
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<td>HBL1223</td>
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<td>120/277</td>
<td>4-way</td>
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<td>277</td>
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</table>
NOTES

1. For snap switches, designation is the same as the symbol used on plans for the device. Type of switch is determined from plan context including type of device or circuit being controlled.
2. Pilot light “on” when switch is “on.”
3. Lutron dimmer (refer to 26 05 05 for additional manufacturers). Provide dimmer wattage size to handle load served. Derate dimmer switch per manufacturer’s recommendations where dimmers are ganged together. Provide dimmer model as required based on application, i.e., incandescent, magnetic low voltage, fluorescent magnetic ballast or fluorescent electronic ballast.
4. Refer to Section 26 05 05 for additional acceptable manufacturers. Color of device shall be verified with Architect (ivory, gray, white, etc.).

END OF SECTION
SECTION 26 28 16
ENCLOSED SWITCHES, FUSES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification sections, apply to work of this section.
B. Division 26 Basic Electrical Materials and Methods sections, apply to work of this section.

1.2 SUMMARY
A. Provide all circuit and motor disconnect switch work including fusing, electrical connections to motors, appliance and mechanical equipment as indicated on the drawings and schedules.
B. Types of circuit and motor disconnect switches in this section include the following:
   1. Equipment disconnects.
   2. Appliance disconnects.
C. Applications of electrical power connections specified in this section include the following:
   1. To resistive heaters.
   2. From electrical source to motor starters.
   3. From motor starters to motors.
   4. To lighting fixtures.
   5. To converters, rectifiers, transformers, inverters, rheostats, and similar current adjustment features of equipment.
   6. To grounds including earthing connections.
   7. To panelboards, contactors, time clocks and similar equipment.
D. All switchboards, panelboards, disconnect switches, starters, etc., shall be fabricated by same manufacturer throughout the entire project.

1.3 SUBMITTALS
A. Product Data: Submit manufacturer’s data on circuit and motor disconnect switches, and equipment connectors.
B. Fuse Product Data: For each type of fuse indicated. Include construction details, material, dimensions, descriptions of individual components, and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:
   1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.
      a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
      b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.
2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
4. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse.
5. Fuse sizes for elevator feeders and elevator disconnect switches.

1.4 QUALITY ASSURANCE

A. All equipment shall be in compliance with codes and standards referenced in Section 26 05 02 titled “Electrical Requirements”.

B. UL Compliance: Comply with requirements of UL 98, “Enclosed and Dead-Front Switches.” Provide circuit and motor disconnect switches which have been UL listed and labeled.

C. Comply with UL Std 486A, “Wire Connectors and Soldering Lugs for Use with Copper Conductors,” including, but not limited to, tightening of electrical connectors to torque values indicated.

D. NEMA Compliance: Comply with applicable requirements for NEMA Stds Pub/No. KS 1, “Enclosed Switches,” and No. 250, “Enclosures for Electrical Equipment (1000 Volts Maximum).”

E. ANSI Compliance: Comply with applicable requirements of ANSI C97.1, “Low-Voltage Cartridge Fuses 600 Volts or Less.”

F. NEMA Compliance: Comply with NEMA FU1 for cartridge fuses.

1.5 PROJECT CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F (5 deg C) or more than 100 deg F (38 deg C), apply manufacturer's ambient temperature adjustment factors to fuse ratings

PART 2 - PRODUCTS

2.1 CIRCUIT AND MOTOR DISCONNECT SWITCHES

A. Furnish and install safety switches as required for motor outlets or other equipment. Switches shall be of size, number of poles, and fused or non-fused, as required for job conditions and the National Electrical Code.

B. Switches shall be equipped with fuse contacts and jaws which ensure positive fuse and jaw contact by means of reinforcing spring clips of other approved means. All current carrying parts shall be silver-plated. Hinges shall be non-current carrying. Switches shall be so designed that they can be locked in either open or closed position.

C. All safety switches shall be NEMA 1 enclosed Type “HD” (heavy duty) quick-make, quick-break, and have interlocking cover with handle that may either be front or side operating with padlocking provisions. Provide NEMA 3R weather proof enclosures where indicated on the drawings or exposed to exterior or damp locations. Incorporate rejection clips where used with Class “R” fuses.
D. Fusible Switches: Heavy duty switches, with fuses of classes and current ratings indicated on drawings. See Section “2.3” for Fuse specifications. Where current limiting fuses are indicated, provide switches with non-interchangeable feature suitable only for current limiting type fuses.

E. Non-fusible Disconnects: Heavy duty switches of classes and current ratings as indicated on drawings.

F. Double-Throw Switches: Heavy duty switches of classes and current rating as indicated on drawings.

G. Bolted Pressure Switches: Bolted pressure switches conforming to and listed under UL Standard 977; single or double-throw arrangement as indicated. For fusible units provide fuses as indicated on drawings.

H. Accessories:
   1. Electrical Interlocks: Provide (1) N.O. and (1) N.C. interlock contacts in all switches.
   2. Special Enclosure Material: Provide special enclosure material as follows for switches indicated on drawings to be NEMA 4X:
      a. Stainless Steel Type 316.
      b. Heavy case aluminum.

2.2 CONNECTIONS FOR EQUIPMENT

A. General: For each electrical connection indicated provide complete assembly of materials, including but not necessarily limited to, pressure connectors, terminals (lugs), electrical insulating tape, electrical solder, electrical soldering flux, heat-shrinkable insulating tubing, cable ties, solderless wirenuts. All other items and accessories as needed to complete splices and terminations of types indicated.

B. Metal Conduit, Tubing and Fittings:
   1. General: Provide metal conduit, tubing and fitting of types, grades, sizes and weights (wall thicknesses) indicated for each type service. Where types and grades are not indicated, provide proper selection as determined by Installer to fulfill wiring requirements and comply with NEC requirements for raceways. Provide products complying with Section 26 05 06 titled “Basic Materials and Methods” and Section 26 05 33 titled “Raceways and Boxes” and in accordance with the following listing of metal conduit, tubing and fittings:
      a. Rigid steel conduit.
      b. Rigid metal conduit fittings.
      c. Electrical metallic tubing.
      d. EMT fittings.
      e. Flexible metal conduit.
      f. Flexible metal conduit fittings.
      g. Liquid-tight flexible metal conduit.
      h. Liquid tight flexible metal conduit fittings.

C. Wires, Cables, and Connectors:
   1. General: Provide wires, cables and connectors complying with Division 26 05 06 titled “Basic Materials and Methods” and “Section 26 05 19” titled “Electrical Power Conductors and Cables.”
   2. Wires/Cables: Unless otherwise indicated, provide wires/cables (conductors) for electrical connections which match, including sizes and rating, of wires/cables which are supplying
electrical power. Provide copper conductors with conductivity of not less than 98% at 20°C (68°F).

3. Connectors and Terminals: Provide electrical connectors and terminals which mate and match, including sizes and ratings, with equipment terminals and are recommended for use by equipment manufacturer for intended applications.

4. Electrical Connection Accessories: Provide electrical insulating tape, heat shrinkable insulating tubing and boots, electrical solder, electrical soldering flux, wire nuts and cable ties as recommended for use by accessories manufacturers for type services indicated.

2.3 FUSES

A. General: Except as otherwise indicated, provide fuses of types, sizes, ratings, and average time-current and peak let-through current characteristics, which comply with manufacturer’s standard design, materials, and constructed in accordance with published product information, and with industry standards and configurations.

B. Class RK1 dual element time-delay fuses: Provide UL Class RK1 current limiting time-delay fuses rated 600-volts, (250 volts where specified), 60 Hz, with 200,000 RMS symmetrical interrupting current rating for protecting circuit breakers, motors and panelboards.

C. Class RK5 dual element time-delay fuses: Provide UL Class RK5 current limiting time-delay fuses rated 600 volts, (250 volts where specified), 60 Hz, with 200,000 RMS symmetrical interrupting current rating for protecting circuit breakers, motors, and transformers.

D. Class L time-delay fuses: Provide UL Class L time-delay fuses rated 600 volts, 60 Hz, with 200,000 RMS symmetrical interrupting current rating.

2.4 SPARE-FUSE CABINET

A. Characteristics: Wall-mounted NEMA-1 steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull. Cabinet shall be located in the main electrical room.

1. Size: Adequate for storage of spare fuses specified in Section 3.3 with 15 percent spare capacity minimum.

2. Finish: Gray, baked enamel.

3. Provide engraved, plastic laminate label “Spare Fuses” for cabinet. Refer to Section 26 05 53 for more information.

4. Fuse Pullers: For each size of fuse, where applicable and available, from fuse manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION OF CIRCUIT AND MOTOR DISCONNECT SWITCHES

A. Install circuit and motor disconnect switches as indicated, complying with manufacturer’s written instructions, applicable requirements of NEC, NEMA, and NECA’s “Standard of Installation,” and in accordance with recognized industry practices.

B. Coordinate circuit and motor disconnect switch installation work with electrical raceway and cable work, as necessary for proper interface.

C. Install disconnect switches for use with motor-driven appliances, and motors and controllers within sight of controller position unless otherwise indicated.

D. Provide control wiring as needed for motor disconnect to remote VFD controller.
3.2 INSTALLATION OF EQUIPMENT CONNECTIONS

A. Install electrical connections in accordance with equipment manufacturer’s written instructions and with recognized industry practices, and complying with applicable requirements of UL, NEC and NECA’s “Standard of installation” to ensure that products fulfill requirements.

B. Coordinate with other work, including wires/cables, raceway and equipment installation, as necessary to properly interface installation of electrical connections for equipment with other work.

C. Connect electrical power supply conductors to equipment conductors in accordance with equipment manufacturer’s written instructions and wiring diagrams. Mate and match conductors of electrical connections for proper interface between electrical power supplies and installed equipment.

D. Cover splices with electrical insulating material equivalent to, or of greater insulation resistivity rating, than electrical insulation rating of those conductors being spliced.

E. Prepare cables and wires, by cutting and stripping covering armor, jacket, and insulation properly to ensure uniform and neat appearance where cables and wires and terminated. Exercise care to avoid cutting through tapes which will remain on conductors. Also avoid “nicking” copper conductors while skinning wire.

F. Trim cables and wires as short as practicable and arrange routing to facilitate inspection, testing and maintenance.

G. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturers published torque tightening values for equipment connectors. Accomplish tightening by utilizing proper torque tools, including torque screwdriver, beam-type torque wrench, and ratchet wrench with adjustable torque settings. Where manufacturer’s torque requirements are not available, tighten connectors and terminals to comply with torque values contained in UL 486A.

H. Provide PVC-coated conduit and fittings for highly-corrosive atmospheres.

I. Provide flexible conduit for motor connections, and other electrical equipment connections, where subject to movement and vibration.

J. Provide liquid-tight flexible conduit for connection of motors and other electrical equipment where subject to movement and vibration, and also where connections are subjected to one or more of the following conditions:

1. Exterior location.
2. Moist of humid atmosphere where condensation can be expected to accumulate.
3. Corrosive atmosphere.
5. Dripping oil, grease, or water.

K. Fasten identification markers to each electrical power supply wire/cable conductor which indicates their voltage, phase and feeder number in accordance with Division 26 section titled “Electrical Identification.” Affix markers on each terminal conductor, as close as possible to the point of connection.

L. Provide flexible metal conduit or Type “S” rubber cords, pigtailed, caps, etc., as required to constitute an operating system. All flexible cords shall have a grounding conductors. Ground
all equipment. See Section 26 05 26 titled “Grounding and Bonding” for additional requirements.

M. Prior to roughing-in, refer to all equipment manufacturer’s shop drawings for details of equipment connections. Provide receptacles as required to match the cord caps on the equipment furnished. Provide either direct wiring or receptacles for final connection to equipment as required for the particular equipment furnished regardless of the type of outlet shown on the plans.

3.3 INSTALLATION OF FUSES

A. Install fuses as indicated, in accordance with manufacturer’s written instructions and with recognized industry practices to ensure that protective devices comply with requirements. Comply with NEC, and NEMA standards for installation of fuses.

B. Coordinate work including electrical wiring, as necessary, to interface installation of fuses with other trades.

C. Install fuses in fused switches.

D. Provide spare fuse cabinet located in the main electrical room. Provide spare fuse of size and type for every five (5) fuses installed. A minimum of three (3) spare fuses shall be provided for each size installed.

3.4 GROUNDING

A. Provide equipment grounding connections, sufficiently tight to assure a permanent and effective ground for electrical disconnect switches.

3.5 FIELD QUALITY CONTROL

A. Testing: Subsequent to completion of installation of electrical disconnect switches, energize circuits and demonstrate capability and compliance with requirements. Except as otherwise indicated, do not test switches by operating them under load. However, demonstrate switch operation through six opening/closing cycles with circuit unloaded. Open each switch enclosure for inspection of interior, mechanical and electrical connections, fuse installation, and for verification of type and rating of fuses installed. Correct deficiencies then retest to demonstrate compliance. Remove and replace defective units with new units and retest.

END OF SECTION
SECTION 26 51 13
LIGHTING FIXTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including general and supplementary conditions and Division-1 Specification sections, apply to work of this section.

B. Division-26 Basic Electrical Materials and Methods sections apply to work specified in this section.

C. Refer to Appendix "C" for Light Fixture Cutsheets

1.2 SUMMARY

A. Extent, Relative location, and details of lighting fixture work are indicated on drawings and in schedules. Refer to Architectural Reflected Ceiling (landscape Architect) Plans for precise fixture locations.

B. Types of lighting fixtures in this section include the following:

2. Fluorescent.
3. Light Emitting Diode, LED
4. Other lamps as noted on fixture schedule.

C. Fixture: A complete lighting unit includes lamps, wiring, controls and parts required to securely support fixture.

D. Exact ceiling construction shall be verified and coordinated with fixture type and mounting prior to ordering. Minor changes in ceiling construction shall not be an extra cost to the project.

1. All materials, accessories, and any other equipment necessary for the complete and proper installation of all lighting fixtures included in this Specification shall be furnished by the Contractor.

2. Fixtures shall be manufactured in strict conformance with the Contract Drawings and Specifications.

3. Specifications and scale drawings are intended to convey the salient features, function and character of the fixtures only, and do not undertake to illustrate or set forth every item or detail necessary of the work.

4. Minor details, not usually indicated on the drawings nor specified, but that are necessary for the proper execution and completion of the fixtures, shall be included, the same as if they were herein specified or indicated on the drawings.

5. The Owner shall not be held responsible for the omission or absence of any detail, construction feature, etc., which may be required in the production of the fixtures. The responsibility of accurately fabricating the fixtures to the fulfillment of this specification rests with the Contractor.

E. Where a catalog number and a narrative or pictorial description is provided, the written description shall take precedence and prevail.
F. General Contractor shall provide electrical subcontractor with entire lighting specification (including fixture cut sheets, illustrations and sketches); electrical subcontractor shall provide each specified manufacturer with complete information about the fixtures they will supply.

G. The contractor shall include the installation of an additional 20 exit signs in the base price for future request for exit signs by the Fire Department or Building Official.

H. Fixture details shown may be modified by the manufacturer provided all of the following conditions have been met:

1. Fixture performance is equal or improved.
2. Structural, mechanical, electrical, safety, and maintenance characteristics are equal or improved.
3. Cost to the Owner is reduced or equal.
4. Modifications have been reviewed by the Architect and have been approved by the Architect in writing.

1.3 SUBMITTALS

Submit shop drawings, samples, and prototypes as specifically instructed below.

A. Shop drawings shall include but not be limited to:

1. For standard catalog items with no modifications, submit catalog cut sheets prepared by the manufacturer which clearly show all elements to be supplied and all corresponding product data (including lamping; ballast manufacturer and model number; voltage; accessories or options and any miscellaneous items detailed in the written description of the specification). If cut sheet shows more than one (1) fixture type, all non-applicable information shall be crossed out.
2. For lamps, submit catalog cut sheets prepared by the manufacturer which clearly shows manufacturer, CRI, CT, wattage, base type, lumen output, lamp life, and any other pertinent information.
3. For custom fixtures, modified fixtures or linear fluorescent fixtures mounted in continuous rows, submit a reproducible drawing prepared by the manufacturer showing all details of construction, lengths of runs, lamp layout, pendant locations, power locations, finishes and list of materials. Drawings must be to scale. Contractor shall provide manufacturer with field dimensions where required.
4. For all submittals under paragraphs 1 through 3 above, manufacturer shall provide submittals within two weeks of receipt of order. All submittals shall have project name and fixture type clearly shown.
5. The Architect/Engineer shall make the final determination as to whether or not the submittal contains sufficient information and reserves the right to request a shop drawing if the fixture cut is insufficient.
6. Maintenance Data: Submit maintenance data and parts list for each lighting fixture, accessory and also include “trouble-shooting” maintenance guide. In addition to the product data and shop drawings, a maintenance manual in accordance with general requirements of Division 1 shall be provided.

B. Samples:

1. It shall be the responsibility of the Contractor to provide a sample(s) fixture as indicated in LIGHTING FIXTURE SCHEDULES or as stated herein. When samples are called for the manufacturer shall provide two working samples, unless otherwise noted, complete with lamp, ballast (rated for 120 volt operation) and 6’ pig-tail 3-prong Edison plug.
2. The sample(s) shall be shipped to a location that is determined by the Architect. Shipping and return shipping costs shall be provided as part of the contract.
3. The purpose of the sample is to review manufacturing techniques, detailing, lamping and scale. Sample fixtures must be approved prior to fabrication of fixtures for the project. Minor modifications, if any, shall be considered part of these Specifications and shall be accomplished with no additional cost to the Owner.

4. Sample fixtures may not be used on the project.

5. In the event the submissions are disapproved, the fixtures will be returned to the contractor to immediately make a new submission of fixture or fixtures meeting the contract requirements.

6. All costs associated for samples are to be paid by the Contractor. No additional costs to the Owner for samples or mockups will be allowed.

C. Shop drawings and samples requested shall be submitted for approval before fabrication. Any material produced prior to the approval of shop drawings or samples, and not in conformance with the Contract Documents, shall be disapproved with the Contractor bearing full responsibility and cost.

D. No variation from the general arrangement and details indicated on the drawings shall be made on the shop drawings unless required to suit the actual conditions on the premises, and then only with the written acceptance of the Architect. All variations must be clearly marked as such on the drawings submitted for approval.

E. Mock-ups:

1. It shall be the responsibility of the Contractor to provide a mock-up of the lighting fixture or lighting systems as indicated in the fixture descriptions. The mock-up shall be erected within a time period and in a location that is acceptable to the Architect. A minimum of five (5) mock ups are anticipated.

2. The mock-up installation shall closely conform to the conditions of the actual installation as to: height, distance from ceiling, number and type of lamps, material, color and etc. The Contractor shall submit a written description of each proposed mock-up with drawings in order to obtain the Architect’s approval prior to commencement of each mock-up.

3. The purpose of the mock-up will be to study the general appearance and performance of the intended lighting systems. At that time, certain minimal test variations may be requested as to lamp location, lamp type, reflector shape, color and etc. Final modifications, if any, shall be considered a part of these Specifications and shall be accomplished with no additional cost to the Owner.

4. Contractor shall modify existing lab mock-up lighting to reflect final design.

F. Substitutions: Manufacturers or light fixtures not listed on fixture schedule must be prequalified prior to bid. This is demonstrated by an “Approved Alternate” listing in the manufacturer column. It in no way implies approval. For approval of all manufacturer(fixture substitutions, the bidders shall comply to specifications herein and as outlined below for submitting alternate fixtures:

1. No substitutions shall be accepted when the LIGHT FIXTURE SCHEDULE includes a three name manufacturer specification.

2. Manufacturer shall have not less than five years experience in design and manufacture of lighting fixtures of the type and quality shown. Prequalification submissions must include a list of completed projects and data catalogue pages and drawings indicating length of experience.

3. Bidders wishing to obtain approval on brands other than those specified by name and catalog number or as an approved alternate in LIGHTING FIXTURE SCHEDULE shall submit their requests not later than fifteen (15) business days before the bid opening. Approval will be in the form of an addendum to the specifications issued to all prospective

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bidders indicating that the additional brand or brands are approved, as equal to those specified as far as the requirements of the project are concerned.

4. If the bidders do not elect to obtain prior approval during the time so specified above, the Owner/Architect/Engineer or Lighting Designer has no obligation to review or consider any such article after the contract award.

5. Contractor shall pay professional fees at current standard hourly rates and reimburse expenses directly to all designers (Architect, Engineer and Lighting Designer) for time spent reviewing substitutions proposed by the Contractor after the bid has been awarded. If payment by the Contractor is not made within 60 days of invoice date, the Owner shall deduct the amount due from subsequent payments to the Contractor in order to reimburse designers.

6. Request for approval shall be accompanied by working fixture samples (with an appropriate lamp, complete photometric, mechanical and electrical data, list of materials and finishes and unit cost to the Owner) of both the specified brand and the proposed substitutes as required to make complete comparison and evaluation. These samples shall be in addition to those required by Lighting Fixture Specification. The above data shall be delivered separately to the Architect and the Engineer. The fixture samples shall be furnished and installed at the bidder’s expense, at a location selected by the Architect. In addition, the bidder shall furnish the Architect and the Engineer with the name and location of at least one completed project where each proposed substitute has been in operation for a period of at least six (6) months, as well as the names and addresses of the Owner, the Architect and the Engineer.

7. Point by point lighting calculations of areas affected by proposed substitution will be done by the bidder for review.

8. The Architect and Engineer shall determine whether the prototype sample complies with the specifications and shall reserve the right to disqualify any bidders.

9. When required and requested by the Architect, or Engineer, samples submitted as per above shall be subjected to photometric, thermal, mechanical, electrical or water testing at an independent test laboratory at no expense to the Owner.

1.4 QUALITY ASSURANCE

A. Manufacturer’s Qualifications: Firms regularly engaged in manufacture of lighting fixtures of sizes, types and ratings required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Installer’s Qualifications: Firms with at least 5 years of successful installation experience on projects with lighting fixture work similar to that required for this project.

C. Codes and Standards:

1. Electrical Code Compliance: Comply with applicable local code requirements of the authority having jurisdiction and NEC Articles 220, 225, 250, 410, and 500 as applicable to installation and construction of building lighting fixtures.

2. NEMA Compliance: Comply with applicable requirements of NEMA Stds Pub/No’s LE 1 and LE 2 pertaining to lighting equipment.

3. IES Compliance: Comply with IES RP-1 pertaining to office lighting practices and RP-15, regarding selection of illuminance values for interior office lighting. Comply with IES RP-8, 19, 20, and PB-15 pertaining to exterior, parking, and roadway lighting practices and fixtures.

4. UL Compliance: Comply with UL standards, including UL 486A and 486B, pertaining to lighting fixtures. Provide lighting fixtures and components which are UL-listed and labeled.

5. CBM Labels: Provide fluorescent lamp ballasts which comply with Certified Ballast Manufacturer’s Association standards and carry the CBM label.
D. Special Listing and Labeling: Provide fixture for damp locations, wet locations, recessed in rated ceilings and walls, hazardous that are UL listed and labeled for specific use.

E. Materials and Equipment:

1. Materials, equipment, and appurtenances as well as workmanship provided under this Section shall conform to the highest commercial standards, and as specified and as indicated on drawings. Fixture parts and components not specifically identified or indicated shall be made of materials most appropriate to their use or function and as such resistant to corrosion and thermal and mechanical stresses encountered in the normal application and function of the fixtures.

2. All fixtures shall be manufactured to a consistent level of quality. Size, color, and component parts shall be identical for all fixtures of the same type.

1.5 DELIVERY, STORAGE, HANDLING, AND WARRANTY

A. Deliver lighting fixtures in factory-fabricated containers or wrappings, which properly protect fixtures from damage.

B. Store lighting fixtures in original packaging. Store inside well-ventilated area protected from weather, moisture, soiling, extreme temperature, humidity, laid flat and blocking off ground.

C. Handle lighting fixtures carefully to prevent damage, breaking, and scoring of finishes. Do not install damaged units or components; replace with new.

D. Provide a 5-year warranty of failure in materials, workmanship, ballast, etc., in addition to and not limited to other rights the Owner may have under the contract documents. A full warranty shall apply for the first year, and a prorated warranty for the last four years.

1.6 SEQUENCING AND SCHEDULING

A. Coordinate with other work including wires/cables, electrical boxes and fittings, and raceways to properly interface installation of lighting fixtures with ceiling requirements.

B. Sequence lighting installation with other work to minimize possibility of damage and soiling during remainder of construction.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. The Contractor shall base bid for lighting fixtures on the manufacturers listed on the fixture schedule only.

B. Alternate manufacturer’s identification by means of manufacturer’s names is to establish basic features and performance standards. Alternate manufacturer’s or substitutions must meet or exceed the standards of the primary manufacturer listed.

C. Qualifications: The contractor is allowed 60 days after the contract has been awarded to submit independent photometric tests and samples for all approved alternate fixtures. If these fixtures fail to comply with the specification requirements at that time, the Contractor will furnish acceptable fixtures at no additional cost to the Owner and with no delay to the project.
D. Any submittals for cost reduction alternates or value engineering shall include unit prices for the specified manufacturer, the specified equal manufacturer, and the proposed alternates. Refer to Part 1.3 for approval process.

2.2 CUSTOM FIXTURES MATERIAL, FABRICATION AND FINISHES (IF REQUIRED)

A. Provide materials as specified with the following characteristics:

1. Stainless Steel:
   a. AISI Type 302 or UNS Type S30200 18-8 grade: 18 percent chromium and 8 percent nickel. Austentitic grain structure with excellent corrosion resisters and high strength.
   b. AISI Type 316: Most resistant to salt spray and industrial fumes for use in these applications.
   c. AISI Type 430: Most economical Ferritic Chromium Steel, very good corrosion resistance, for use only where specified.

2. Galvanized Steel: Coated steel with zinc by a method of hot dipping on electroplating.


4. Bronze: Copper alloy, principal alloying elements are phosphor, aluminum, silicon, and tin.

5. Brass: Copper alloy, principal alloying element is zinc. Wrought brass is of UNS designation C20000, C30000, C40000, C66400 to C69800. Cast brass includes leaded red brass (C83600), leaded semi-red brass (C84400), and yellow and leaded yellow brass (C85200 to C85700).

6. Copper: A pure metal. Copper or high copper alloy containing less than 6 percent alloying elements. Wrought copper has UNS designation C10000. Cast copper has UNS designation C80100 to C82800.

7. Zinc: A pure metal. May be specified as an alloying element in copper and aluminum.

8. Glass: All glass shall be heat strengthened (tempered) clear float glass should conform to the requirements of Federal Specification DD-G-1403B, transmittance not less than 88 percent or laminated safety glass. For exterior fixtures, use Borosilicate glass, tempered, Corning #7740. For fixtures directly exposed to the elements and aimed above horizontal with radiant energy of 4.16 watts per square inch or greater, use Vycor glass.

9. Acrylic: 100 percent virgin acrylic polymer, colorless.

10. Neoprene: All neoprene rubber should be heat resistant to withstand heat generated by lamp operation.

11. Silicone: A plastic based on silicon which is not an organic compound. Suitable for use in a wide temperature range (-80 to +500ºF). Used as an additive to plastic to improve adhesion, increase strength, and improve water resistance.

B. Provide thickness of metal required or as specified so that all fixture are rigid, stable and will resist deflection, twisting, warping or bending under normal installation procedures, loading, relamping, etc.:

1. All steel luminaire housings minimum 22 gauge cold rolled steel.
2. All aluminum extrusion housings minimum 0.125” thick.
3. All spun, hydroformed, or sheet aluminum reflectors fabricated from #12 aluminum sheets, minimum 15 gauge, 0.57” or heavier.
4. All cast aluminum or bronze housings minimum of 0.375” thick.
5. All sheet bronze, steel, aluminum or other metal plate minimum of 22 gauge.

C. Fasteners shall be manufactured of non-magnetic stainless steel, except in indoor applications where galvanized steel is acceptable in non-visible locations. Provide tamperproof screws in all fixtures mounted below 8’ above finished floor.
D. Refer to other parts of this section for additional material and fabrication requirements.

E. Fixture finishes shall be applied in a manner that will assure a durable, wear resistant surface.

1. Prior to finishing, all surfaces shall be free from foreign materials such as dirt, rust, oil, polishing compounds and mold release agents.
2. Where necessary, surfaces shall be hot cleaned by accepted chemical means and shall receive corrosion inhibiting (phosphating) treatment assuring positive paint adhesion.
3. Exposed metal surfaces used in interior areas, except chromium plated parts, shall be given an even coat of high grade methacrylate lacquer, or transparent epoxy with a satin finish.
4. All castings, extrusions, and spinings shall be machined, sanded or similarly treated, and given minimum one coat of baked-on clear methacrylate lacquer, unless a painted finish is specified, to provide a consistent texture, color, and finish throughout all exposed surfaces.
5. Exterior metal surfaces such as extruded parts or castings which do not otherwise receive a finishing coating, shall be machined, sanded or similarly treated. All such finished components shall be given a minimum of one coat of baked-on clear methacrylate lacquer, satin finish, unless an alternate finish is specified.
6. Aluminum surfaces exposed to the weather shall receive a duronodic or polyester powder paint or clear methacrylate lacquer finish as specified for corrosion resistance. When in contact with concrete, aluminum shall be coated with bituminous paint, zinc chromate primer, or separated by a layer of plastic or other gasketing material. Creosote and tar coatings should not be used because of their acid contents.
7. For weatherproof and vaportight fixtures, painted finishes and accessories shall be weatherproof enamel using proper primers or galvanized and bonderized epoxy in accordance with the manufacturer’s requirements. Unless otherwise specified, all painted surfaces shall have an outdoor weatherproof life expectancy of not less than 20 years.
8. Sheet steel fixture housings, iron and steel parts, which have not received phosphating treatment (“Bonderizing” or similar process) or are to be utilized in exterior applications shall be made corrosion resistant by zinc or cadmium plating, or hot-dip zinc galvanizing after completion of all forming, welding, or drilling operations. Where aluminum parts come in contact with steel (or other metals), the steel shall be zinc plated or cadmium plated. Minimum thickness of above protective coatings shall be:
   a. Hot galvanized zinc coating - 0.0005”.
   b. Cadmium plating - 0.00015”.
9. Parts operated under temperatures injurious to hot-dipped galvanizing shall be electroplated.
10. Where aluminum parts come in contact with bronze parts, apply to both surfaces a coating of Corogard No. 1706 as manufactured by Minnesota Mining & Manufacturing Company.

F. Completely form painted reflectors before application of primer and enamel color coats. Reflectors and reflector bodies for fluorescent lamp fixtures having baked-on white enamel finish, shall be made of steel of the thickness specified and given a suitable primer and white color coats properly applied to meet all applicable requirements and tests.

G. When requested by the Architect and Engineer, the Contractor shall submit a sufficient quantity of flat metal panels having the identical primer and color coats applied in the same manner as proposed for the Contract items, for subjection to any one or all of the tests listed herein by an approved independent testing laboratory. Provide panels of suitable size and drilled as necessary for a particular test procedure. The Contractor shall bear the cost of all required tests.
H. Wire leads to the receptacle or connector of any side-prong incandescent lamp or any “cool-beam” lamp utilizing a dichroic reflector shall be SF-2 (silicone rubber insulated) stranded wire (minimum No. of 18 AWG). Wire within housing shall be entirely covered with a flexible woven fiberglass sleeve.

I. All reflectors shall be finished according to the minimum requirements outlined below.

<table>
<thead>
<tr>
<th>CLASS</th>
<th>MIN. WEIGHT OF COATING (mg/sq.in)</th>
<th>SERVICE</th>
<th>% MINIMUM REFLECTIVITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>MI</td>
<td>0.5</td>
<td>Normal interior service.</td>
<td>83 75</td>
</tr>
<tr>
<td>SI</td>
<td>7.5</td>
<td>Medium service, interior industrial, exterior when operated within glass.</td>
<td>82 73</td>
</tr>
<tr>
<td>SE</td>
<td>10.0</td>
<td>Exterior industrial or commercial service, exposed to atmosphere. Marine service enclosure.</td>
<td>78 65</td>
</tr>
</tbody>
</table>

J. All reflector and baffles of modified elliptical contour cross section shall have with no apparent brightness from above 40° above the nadir, and with no lamp image or any part of the lamp visible from above 40° above the nadir.

K. Cone flange shall be formed as an integral part of the cone and with an identical color and finish. Width of the flange covers all ceiling openings without light leaks or hardware visible.

L. Samples of colored aluminum finishes (black, brass, bronze, etc.) shall be submitted for approval before fabrication.

M. All glass lenses shall be heat treated (tempered) or sealed with a clear acrylic laminate layer to provide a “safety glass” rating. All lenses which require removal for relamping or normal maintenance shall be attached to the fixture housing by a minimal length of safety chain to prohibit the lens from falling and striking surrounding surfaces. Glass edges exposed during the relamping process gasketed to prevent chipping or cracking. Glass lenses shall be a minimum 0.375” thick.

N. Glass lenses specified as translucent or “opal” shall be treated as follows:

1. Sand blasted.
2. Acid etched.
3. White flashed.

2.3 MATERIALS AND FABRICATION

A. Provide thickness of metal required or as specified so that all fixture are rigid, stable and will resist deflection, twisting, warping or bending under normal installation procedures, loading, relamping, etc.

B. Provide neoprene or silicone gasketing, stops, and barriers where required to prevent light leak or water and water vapor (penetration).
C. Provide finished product with ground metal edges, tight fitting connections, hinges and closures; clean, neat edges, trims, and frames; continuous welds, ground smooth with sharp corners; all exposed screws countersunk flush.

D. Provide positive, durable means of connection at all joints as required.

E. All cast parts, including die-cast members, shall be of uniform quality, free from blow holes, pores, hard spots, shrinkage defects, cracks or other imperfections that affect strength and appearance or are indicative of inferior metals or alloys.

F. Provide sufficient ventilation for lamps, ballasts and transformers including vent holes where required. Outdoor fixtures shall have corrosion resistant wire mesh screens in the vent holes.

G. All adjustable fixtures shall be provided with reliable locking device to secure aiming angles of the fixture housing or lamp yoke as well as lamp and lens orientation devices to secure oval beam pattern lamps and/or spread lenses.

2.4 FINISHES

A. Fixture finishes shall be applied in a manner that will assure a durable, wear resistant surface.

1. Prior to finishing, all surfaces shall be free from foreign materials such as dirt, rust, oil, polishing compounds and mold release agents.
2. Where necessary, surfaces shall be hot cleaned by accepted chemical means and shall receive corrosion inhibiting (phosphating) treatment assuring positive paint adhesion.
3. Provide all ferrous metal surfaces with a protective finish having rest-inhibiting properties. Painted finishes shall be a minimum of 1.5 mils thick and shall have a balance between hardness and bending properties suitable for application. White finishes shall have 87 percent minimum reflectance. Application and cleaning shall be performed so as to prevent any loss of reflectance capability.

2.5 WIRING

A. All wiring shall comply with the following:

1. All wiring devices within lighting fixtures or from the fixture to the splice with the project branch circuit wiring shall be as specified below.
2. Wiring between fluorescent lampholders and associated operating and starting equipment shall be of similar or heavier gauge than the leads furnished with the approved types of ballasts with equal or better insulating and heat resisting characteristics.
3. Wiring shall be protected with tape or tubing at all points where abrasion may occur.
4. Wiring shall be concealed within the fixture construction except where design or mounting dictates otherwise.
5. Connections of wires to terminals of lampholders and other accessories shall be made in a neat and workmanlike manner and electrically and mechanically secure with no protruding or loose strands. The number of wires extending to or from the terminals of a lampholder or other accessory shall not exceed the number which the accessory is designed to accommodate.
6. Joints in wiring within lighting fixtures and connections of the fixture wiring to the wiring of the building shall be specified in Division 26.
7. Wiring channels and wireways shall be free from projections and rough or sharp edges throughout, and all points or edges over which conductors must pass and may be subject to injury or wear shall be rounded and bushed.
8. Insulated bushings shall be installed at points of entrance and exit of flexible wiring.
9. Junction boxes attached to lighting fixtures shall be manufactured in accordance with the National Electrical Code and approved for the number of conductors indicated on the
drawings. Supplementary junction boxes shall be installed where required to comply with Code.

10. When exposed, all junction boxes and conduit to be painted as per the Architects’ direction at no additional cost to the Owner.
11. Cord types shall be suitable for application and be fitted with proper strain relief and watertight entries where required by application.
12. Furnish code approved wiring in ceiling cavities forming air plenums.

2.6 MARKING OF FIXTURES

A. Fixtures designed for voltages other than 110-125 volts shall be marked with operating voltage.

B. Fixtures equipped for operation of rapid start lamps shall be clearly marked “USE RAPID START LAMPS ONLY.”

C. Fixtures designed for operation of lamps below the rated enclosure maximum shall be clearly marked “Lamp Watts Not to Exceed _______” to maintain the design energy load.

2.7 SOUND TRANSMISSION

Sound transmission through the light fixture units, when spaced as indicated on drawings, shall be sufficiently attenuated to maintain speech privacy between adjoining spaces. Contractor to provide insulating battens around the fixtures where sound transmission levels are unacceptable.

2.8 THERMAL PROTECTORS

A. Provide thermal protectors as required by the N.E.C., or as required by local Code, to prevent operation of lighting fixtures in enclosed spaces or adjacent to combustible materials at temperatures at or above 90°C (194°F).

B. Fixtures approved for operation in fire-resistant material at temperatures up to 150°C (302°F) shall be plainly marked.

C. All incandescent fixtures shall be provided with thermal protectors except where otherwise indicated or where approved for operation without such protectors by the N.E.C. and by the local building authority.

2.9 LAMPS

A. Provide lamps as shown in the fixture schedule or as modified in reviewed shop drawings.

B. Lamps as specified for the individual luminaries or lighting equipment shall be delivered and installed in fixtures and lighting equipment leaving these completely lamped and in normal operating condition.

C. Hot cathode fluorescent lamps, unless otherwise designated, shall be of the rapid start type only and deliver not less than 2,800 initial lumens for straight 4 ft. T-8 and 5,000 lumens for a 4 ft. T5HO lamps. Fluorescent lamps are triphosphor, color temperature 3,500°K, with a color rendering index of not less than 85, unless noted otherwise. Refer to light fixture schedule for details.

D. Provide all incandescent lamps inside frosted, unless noted otherwise. Refer to light fixture schedule for details.
E. High intensity discharge lamps, unless noted otherwise, shall be color corrected, phosphor coated, mogul base metal halide lamps. The mogul base color rendering index (CRI) shall not be less than 80 and a color shift not exceeding ±400ºK, unless otherwise specified. All medium base metal halide lamps to have a CRI of not less than 80 and color shift not exceeding ±200ºK. Refer to light fixture schedule for details.

F. LED lamp sources shall have a color temperature binning that does not exceed +/-200K. LED lamp life shall be rated at 70% of initial lumens remaining. LED drivers shall be used at 100% output for lumen output rating and be not underdriven or overdriven.

G. Lamps shall be by the same manufacturer and produced by the following acceptable manufacturers:
   1. General Electric Lighting
   2. Osram Sylvania, Inc.
   5. Others only where specified.

2.10 LAMPHOLDERS

A. Lamp sockets shall be rigidly attached to fixture enclosure or housing.

B. High intensity discharge lamp sockets shall be made of heavy duty heat-resistant porcelain.

C. Fluorescent lamp sockets operated with an open circuit voltage in excess of 300 volts shall be of the safety type, and open the supply circuit when the lamp is removed from the sockets.

D. Provide nickel plated brass or nickel and silver plated contacts in all lampholders for tungsten halogen lamps, lamps in outdoor fixtures, and mogul base incandescent, metal halide or mercury vapor lamps.

E. All lamp sockets shall be suitable for the indicated lamps and shall be set so that lamps are positioned in optically correct relation to all lighting fixture components. All adjustable sockets shall be preset at the factory for lamp specified.

2.11 FLUORESCENT AND HIGH INTENSITY DISCHARGE LAMP BALLASTS

A. All fluorescent and high intensity discharge lamp ballasts shall conform to the following:
   1. All ballasts for a particular lamp type shall be of the same manufacturer and where possible all ballasts on the projects be of the same manufacturer.
   2. All ballasts shall be “Class P” indicating approved integral ballast protection. Fuses in the primary leads shall be provided in addition to the “Class P” ballast.
   3. All ballasts shall be of the electronic high power factor type, 0.90 or greater, energy saving, “super low heat” as manufactured by Advance, Philips, Universal, Motorola or approved equal.
   4. All fluorescent ballasts shall be electronic, capable of maintaining a constant light output on all rapid start fluorescent lamps over operating range of 90V to 145V (120V ballast) and 200V to 320V (277 ballast). The total harmonic distortion (THD) of the ballast shall be less than 10 percent of the full light output current level. The ballast shall have a sequenced start progression which first heats cathode filaments and then ignites the lamp. The ballast shall withstand line transients as defined in ANSI/IEEE C62.41, category A; crest factor less than 1.4; power factor greater than 90% and operating frequency of 20KHZ or greater without a visible flicker. The case temperature shall not
The component parts shall be designed, fabricated, and assembled in accordance with the latest requirements of the N.E.C.

9. Ballasts shall provide safe and reliable operation of the specified lamps.

10. Whenever possible, provide two-lamp ballasts for fixtures with two fluorescent lamps or multiples of two lamps.

11. Lamp/Ballast combinations should be used to allow for maximum energy efficiency, unless otherwise specified.

12. Identical ballasts shall be installed within each fixture type.

13. For HID fixtures specified with remote ballasts, the contractor shall verify and coordinate the maximum distance from lamp to ballast allowed.

14. Fixture design, fabrication, and assembly shall be such as to prevent overheating or cycling of lamps and ballasts under normal operating temperature variations.

15. Provide the lowest sound rating available for the lamps specified and clearly show their respective sound ratings. Ballasts found by the Architect or Engineer to be unduly noisy shall be replaced without charge prior to acceptance of the work.

16. Dimming ballasts shall be provided where dimming controls are required per the drawings, notes and schedules. Dimmer type ballasts shall be of a design recognized and approved under the U.L. component program. These ballasts must coordinate with the dimming control devices specified for the particular application. Unless specified in the Lighting Fixture Schedule, all dimming ballasts shall dim to 10%. Basis of design shall be 0-10V dimming ballast.

17. Ballasts intended for outdoor use shall have a minimum lamp starting temperature of 0°F, except as noted otherwise.

18. Where ballasts are remote from fixture housing, provide suitable enclosure for installation with the conduit and wire from the ballast to the lamp socket clearly marked “Caution,” “High Voltage.” All remote ballasts to be installed within the recommended distance from the lamp socket as per the manufacturer with access plates for maintenance and on neoprene pads for sound absorption.

19. Ballast for T5 HO lamps or smaller shall have end of life sensing circuits.

20. Provide internal disconnecting means for ballast maintenance. Disconnecting means shall disconnect all conductors, including grounded conductor.

B. Ballasts manufactured by the following are acceptable:

1. Motorola/GE
2. Advance
3. Universal
4. Osram Sylvania
5. Approved Equal
6. Contractor to coordinate ballast line side voltage with branch circuit voltage as shown on Contract Drawings.

C. LED Lamps

1. Initial delivered lumens – thermal losses should be less than 10% when operated at a steady state at an average ambient operating temperature of 25°C, and optical losses should be less than 15%.

2. Average Delivered Lumens – Average delivered lumens over 50,000 hours should be minimum of 85% of initial delivered lumens.
3. LED boards, drivers and associated components shall have a Warranty of 5 years on the LEDs, 5 years on the driver, 10 years on the paint finish.

4. Driver Specification shall include:
   a. Be Electronic, Voltage range of (120-277) +/- 10%
      1) Current .35 Add (+/- 5%)
      2) Frequency 50/60 Hz
      3) Power Factor >90% at full load
      4) THD <20% at full load
      5) Load regulation: +/- 1% from no load to full load
      6) Output ripple <10%
      7) Output should be isolated
      8) Case temperature: rated for -40º through +80 º
      9) Overheat protection, self-limited short circuit protection and overload protected
      10) Primary fused
      11) Life rating not less than 50,000 hours

2.12 REFLECTORS

A. Reflectors and reflecting cones or baffles shall be as follows:
   1. Absolutely free of any tooling marks including spinning lines, indentations caused by riveting or other assembly techniques.
   2. No rivets, springs, or other hardware visible after installation.
   3. First quality polished, buffed and anodized finish, “Alzak” or approved equal.
   4. Specular finish color as selected by the Architect or as specified in the fixture schedule.

B. Other aluminum reflectors shall be as follows:
   1. Formed and finished as noted on the Drawings and elsewhere in the Specification.
   2. Reflectors free from blemishes, scratches, or indentations which would distort their reflective function.
   3. Finished by means of the “Alzak” process or approved equal unless otherwise noted.

C. Reflector and housing shall comply completely enclose the fixture’s fluorescent lamp in downlights in a plenum ceiling and provide the full rated output of the lamp. Fixtures that vent through the downlight reflector into the plenum are not acceptable.

2.13 LENSES

A. All lenses secured by positive means with neoprene or silicone gasketing or washers as required to hold the lens tight within a frame or attach to housing.

B. All glass lenses shall be heat treated (tempered) or sealed with a clear acrylic laminate layer to provide a “safety glass” rating. All lenses which require removal for relamping or normal maintenance shall be attached to the fixture housing by a minimal length of safety chain to prohibit the lens from falling and striking surrounding surfaces.

C. Acrylic lenses shall be 100 percent virgin acrylic polymer and colorless. For lenses with pattern of pyramids or cones, specified minimum thickness refers to distance from flat surface to base of pyramids (cones), or thickness of undisturbed material. All lenses shall be a minimum .156” thick.

D. The quality of the raw acrylic material must exceed IES, SPI, and NEMA Specifications by at least 100 percent which, as a minimum standard, shall not exceed yellowness factor of 3 after 2,000 hours of exposure in the Fade-o-meter or as tested by an independent test laboratory.
Acrylic plastic lenses and diffusers shall be properly cast, molded or extruded as specified, and shall remain free of any dimensional instability, discoloration, embrittlement, or loss of light transmittance for at least 15 years.

2.14 LOUVERS

A. All louvers shall be fabricated of the specified material.

B. All fluorescent light fixture louvers shall be parabolic and shall be rated at 90 percent or over on the VCP index.

C. Louver finishes shall be provided as specified.

D. All plastic parabolic louvers shall be destaticized before and after fabrication to insure minimum maintenance.

E. All metal louvers shall be coated with anti-rust material and electrostatically painted.

F. All louvers shall be heat tested to withstand lamp operating temperatures with no deformation of shape, paint blistering or discoloration.

2.15 FIXTURE TRIMS

A. Fixtures shall have finish trim designed for the following types of ceiling systems:  Ceiling Type  Trim Type

1. Recessed Incandescent, Fluorescent, LED, or Metal Halide Fixtures
   a. Plaster - Overlap Trim.
   b. Concrete - Overlap Trim.
   c. Tile - Overlap Trim.
   d. Gypsum - Overlap Trim.
   e. Metal Pan, Concealed M - Modular, Fit-in Support.
   f. Lay-in - Modular, Tile with Flush Fit-in.

B. Provide trim details as shown on the Drawings or as specified, which are indicative of appearance and dimensional requirements. The trim finish and dimensions subject to the approval of the Architect.

C. Trimless fixtures shall be installed per manufacture’s guidelines and shall be installed and coordinated with other trades as required.

D. Mitered corners shall be continuously welded and smoothed before shop finish is applied. No lapping of trim metal for all flush mounted ceiling trims for rectangular or square recessed fixtures.

E. Provide a mounting frame or ring with lock recessed or semi-recessed light fixture to secure the mounting frame to the ceiling and support any reflectors, trims, or lenses. Ring shall be compatible with the ceiling and of sufficient strength to rigidly support the fixture and any stress applied in relamping.

F. Catalog numbers are included in the Lighting Fixture Schedule for reference. Provide all accessories and design features described herein regardless of whether such features are included in catalog reference including, mounting hardware, louvers, lenses, filters, transformers, etc.
2.16 LIGHTING FIXTURE TYPES AND CATALOG NUMBERS

A. General: Various fixtures types required are indicated on Lighting drawing Fixture Schedule. Fixtures must comply with minimum requirements as stated herein. Review architectural drawings and specifications to verify and coordinate ceiling types, modules, suspension systems appropriate to installation.

2.17 AUXILIARY SUPPORTS FOR SUSPENDED FIXTURES

A. Provide separate and isolated suspension for all fixtures required by the Local Building Department and seismic requirements. This may include rod hangers, hook hangers, or single stem hangers.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions under which lighting fixtures are to be installed, and associated substrate for supporting lighting fixtures. Notify Contractor in writing of conditions detrimental to proper completion of the work. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to installer.

3.2 INSTALLATION OF LIGHTING FIXTURES

A. Contractor to coordinate exact quantities and critical dimension with field conditions.

B. Contractor to verify and coordinate that appropriate framing, support structures, mounting brackets, and other required structural connections are provided by the General Contractor or other trades to insure a timely, correct and neat installation of all luminaries.

C. Contractor to coordinate and provide any associated mounting hardware, conduit connections, or associated appurtenances to effectively install the luminaries. Provide each light fixture with complete installation instructions. All light fixtures to be installed in strict conformance with manufacturer's recommendations and instructions.

D. Install lighting fixtures in accordance with fixture manufacturer's written instructions, applicable requirements of NEC, NECA's "Standard of Installation," NEMA standards, and with recognized industry practices to ensure that lighting fixtures fulfill requirements.

E. Exact locations of all lighting fixtures including mounting heights and plan dimensions are as per the Architectural and/or Landscape Drawings. Any ambiguities or conflicts in this dimensional information to be identified to the Architect prior to installation.

F. Provide fixtures and/or fixture outlet boxes with hangers to properly support fixture weight. Submit design of hangers, method of fastening, other than specified herein, for review by Architect.

G. Install flush mounted fixtures properly to eliminate light leakage between fixture frame and finished surface.

H. Provide plaster frames for recessed fixtures installed in other than suspended grid type acoustical ceiling systems. Brace frames temporarily to prevent distortion during handling.

I. Fasten fixtures securely to structural supports, and ensure that pendant fixtures are plumb and level. Provide individually mounted pendant (cable or rigid stem), fixtures longer than an
overall length of 2 feet with diagonal corrosion resistant aircraft cable bracing to minimize sway. Provide rigid stem hanger with ball aligners and provisions for minimum one inch vertical adjustment. Mount continuous rows of fixtures with an additional stem hanger greater than number of fixtures in the row.

J. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer’s published torque tightening values for equipment connectors. Where manufacturer’s torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified on UL Stds. 486A and 486B and the National Electrical Code.

K. Support pendant mounted fixtures greater than an overall 2 feet in length at a point in addition to the outlet box fixtures stud with an appropriate safety cable. Certain decorative pendant fixtures may not require a safety cable, verify with Architect, Engineer or Lighting Designer.

L. Fasten electrical lighting fixtures and brackets securely to indicate structural supports, including poles/standards, and ensure that installed fixtures are plum and level.

M. Rigidly align all continuous rows of fixtures for true in-line appearance.

N. Do not install exposed fixtures, reflectors or trims until all plastering and painting that may mar fixture finish is completed. Replace blemished, dented, damaged or unsatisfactory fixtures as directed.

O. Support all fixtures independent of cable trays, ductwork or piping.

3.3 FIELD QUALITY CONTROL

A. Replace defective and burned out lamps for 3 months following the Date of Substantial Completion.

B. At Date of Substantial Completion, replace lamps in lighting fixtures which have been operational over 100 hours.

   1. Refer to Division-1 sections for the replacement/restoration of lamps in lighting fixtures, where used for temporary lighting prior to Date of Substantial Completion.

C. Furnish stock or replacement lamps amounting to 5%, but not less than 4 lamps in each case, of each type and size lamp used in each type fixture. Deliver replacement stock as directed to Owner’s storage space.

3.4 AIMING AND ADJUSTMENT

A. All adjustable lighting units shall be aimed, focused, locked, etc., by the Contractor under observation of the Architect, Engineer or Lighting Designer. All aiming and adjusting shall be carried out after the entire installation is complete. All ladders, scaffolds, etc., required shall be furnished by the Contractor. As aiming and adjusting is completed, locking setscrews and bolts and nuts shall be tightened securely. The aiming and adjustment of luminaires must take place after the projects amenities have been completely installed. These amenities shall include but are not limited to plantings, furniture, artwork, graphics and signage.

B. Where possible, units shall be focused during the normal working day. However, where daylight interferes with seeing, aiming shall be accomplished at night.
3.5 CLEANUP

A. Clean lighting fixtures of dirt and construction debris upon completion of installation. Clean fingerprints and smudges from lenses. Two weeks prior to substantial completion, re-clean all fixtures for dust, fingerprints, and smudges from all visible parts of the fixture.

B. Protect installed fixtures from damage during remainder of construction period.

C. At the time of final acceptance by the Owner, all lighting fixtures shall have been thoroughly cleaned with materials and methods recommended by the manufacturers, all broken parts shall have been replaced, and all lamps shall be operative.

3.6 GROUNDING

A. Provide equipment grounding connections for lighting fixtures as indicating. Tighten connections to comply with tightening torques specified in UL STD 486A to assure permanent and effective grounds.

3.7 DEMONSTRATION

A. Upon completion of installation of lighting fixtures, and after building circuitry has been energized, apply electrical energy to demonstrate capability and compliance with requirements. Where possible, correct malfunctioning units at site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and proceed with retesting.

END OF SECTION
PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes electrical work required to support the Communications Systems specified in Division 27.

1.2 DESCRIPTION OF WORK

A. The Electrical Contractor shall provide electrical work and equipment as called for in the following Division 27 Specification Sections.
   1. Basic Communications Requirements
   2. Bidding
   3. Warranty
   4. Quality Assurance
   5. Common Work - Sleeves, Penetrations, and Firestopping
   6. Common Work - Hangers and Supports
   7. Electrical - General Requirements
   8. Electrical - Grounding and Bonding
   9. Electrical - Conduit and Boxes
   10. Electrical - Cable Trays
   11. Electrical – Underground Ducts and Raceways
   12. Electrical – Maintenance and Hand Holes

B. The requirements of these Sections are additional to, different from, or otherwise supplement the requirements of similar work specified in Division 26.

C. The requirements of these Sections serve as the basis for the requirements of this Section, and are incorporated by reference into this specification Section.

PART 2 - MATERIALS

2.1 THIS SECTION NOT USED

PART 3 - EXECUTION

3.1 THIS SECTION NOT USED

END OF SECTION
SECTION 27 00 10
BASIC COMMUNICATIONS REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY
   A. This Section specifies the basic requirements for communications installations as indicated or required, and includes requirements common to more than one Specification Section of this Division (such as related documents, related Sections, definitions, governing requirements, Contractor requirements, warranty requirements, submittal requirements/procedures, and project closeout requirements/procedures, as well as other requirements).

1.2 RELATED DOCUMENTS
   A. The General Provisions of the Contract (including General and Supplementary Conditions, and the General Requirements of Division 1), apply to the work of this Division.
   B. This Section may expand upon or supplement the General Provisions of the Contract. In the event of a conflict or discrepancy between this Section and the General Provisions of the Contract, the General Provisions of the Contract shall govern. However, if the requirement of this Section (or portion thereof) exceeds that of the General Provisions of the Contract, and is furthermore not contrary to the General Provisions of the Contract, then the requirement of this Section (or portion thereof) shall prevail.
   C. Examine the Construction Documents in their entirety (including Drawings and Specification Sections in the other Divisions) for requirements or work which may affect work under this Section, regardless of whether such requirements or work are specifically indicated in this Section.

1.3 RELATED SECTIONS
   A. All Specification Sections in this Division.
   B. The following Sections in other Divisions:
      1. Division 26 – Electrical for Communications Systems

1.4 COMMUNICATIONS SYSTEMS
   A. The following systems are included within this Division. Following each system is the name of the Division 27 series of Drawings relating to that system:
      1. Communications Cabling: T-Series
      2. Audiovisual: T-Series
      4. Low Voltage: T-Series
      5. Electrical Infrastructure: ET-Series

1.5 INTENT AND INTERPRETATIONS
   A. It is the intent of the Construction Documents that the Contractor shall include all items necessary for the proper execution and completion of the Work by the Contractor, resulting in complete and fully operational system(s) ready for the Owner’s use, in full compliance with all applicable standards, codes and ordinances.
      1. Work or product not specifically indicated in the Construction Documents, but which are necessary to result in complete and fully operational system(s) ready for the Owner’s use, shall be provided by the Contractor.
2. The specification of certain products in the Construction Documents shall not be construed as a release from furnishing such additional products and materials necessary to furnish complete and fully operational system(s) ready for the Owner’s use.

B. The Construction Documents include certain conventions in the use of language and the intended meaning of certain terms, words, and phrases when used in particular situations or circumstances. These conventions include:
1. Abbreviated Language: Language used may be abbreviated. Implied words and meanings shall be interpreted as appropriate. Words implied, but not stated, shall be interpreted as the sense requires. Singular words shall be interpreted as plural and plural words interpreted as singular where applicable and where the full context so dictates.
2. Imperative and Streamlined Language: Imperative and streamlined language is used generally. Requirements expressed in the imperative mood are to be performed by the Contractor. At certain locations in the text, for clarity, subjective language is used to describe responsibilities that must be fulfilled indirectly by the Contractor, or by others when so noted.
3. Abbreviations and Names: Trade association names and titles of general standards are frequently abbreviated. Where abbreviations and acronyms are used, they mean the recognized name of the trade association, standards generating organization, authority having jurisdiction, or other entity applicable to the context.
4. Words used in the singular shall also mean the plural, wherever the context so indicates, and likewise words in the plural shall also mean the singular, wherever the context so indicates.
5. Unless otherwise stated, words which have well known technical or construction industry meanings are used in accordance with such recognized meanings.
6. The terms “directed”, “required”, “permitted”, “ordered”, “designated”, or “prescribed”, as well as similar words shall mean the direction, requirement, permission, order, designation or prescription of the Engineer.
7. The terms “approved”, “acceptable”, “satisfactory”, and similar words shall mean approved by, acceptable, or satisfactory to the Engineer.
8. The terms “necessary”, “reasonable”, “proper”, “correct” and similar words shall mean necessary, reasonable, proper, or correct in the judgment of the Engineer.

C. Assignment of Specialists: The individual Specification Sections may require that certain specific construction activities be performed by specialists who are recognized experts in the operations to be performed. The specialists must be engaged for those activities, and such assignments are requirements over which the Contractor has no choice or option. Nevertheless, the ultimate responsibility for fulfilling the contract requirements shall remain with the Contractor.
1. This requirement shall not be interpreted to conflict with the enforcement of local building codes and similar regulations governing the work.

D. Drawings:
1. Drawings are diagrammatic and approximate in character, are not intended to show all features of required work, and do not necessarily indicate every required component.
2. Symbols used on the Drawings are defined in the legend on the Drawings. Symbols indicated on the legend may not necessarily be required.

E. Drawings and Specifications are complementary. Items required by either are binding as though they are required by both.

1.6 DEFINITIONS
A. The definitions below are applicable to this Division:
1. General
   a. Accepted/Acceptable: Work or materials conforming with the intent of the project, and in general, conforming to the pertinent information in the Construction Documents.
b. Approved/Approval: The written approval of the Engineer.
d. Accessible Ceiling: Acoustical tile hanging ceilings (“Hard-lid” ceilings (concealed spine or sheetrock/gypsum ceilings), even when provided with access panels, are not considered an Accessible Ceiling.)
e. Agreement: The contractual agreement between the Owner and the Contractor.
f. Concealed: Hidden from sight in interstitial building spaces, chases, furred spaces, shafts, crawl spaces, etc.
g. Construction Documents: Collective term for the entire set of bound or unbound material describing the construction and services required, including all Drawings, Specifications, addenda issued prior to execution of the contract, and modifications issued after execution of the Contract (such as change orders, construction change directives, supplemental instructions, etc.).
h. Contract Documents: The Agreement (including other documents listed in the Agreement), Conditions of the Contract (General, Supplementary and other conditions), and the Construction Documents.
i. The Contract: The Contract Documents form the Contract. The Contract represents the entire and integrated agreement between the Owner and the Contractor and supersedes any prior negotiations, representations or agreements, either written or oral. The Contract shall not be construed to create a contractual relationship of any kind (1) between the Engineer and the Contractor, (2) between the Owner and a subcontractor, or (3) between any persons or entities other than the Owner and Contractor.
j. Contractor: The party responsible for providing the system(s) as indicated herein.
k. Drawings: The graphic and pictorial portions of the Contract Documents, wherever located and whenever issued, showing the design, location and dimensions of the Work, generally including (but not limited to) plans, elevations, sections, details, schedules and/or diagrams.
l. Engineer: The party responsible for producing the communication system(s) Construction Documents.
m. Exposed: Not concealed (see above) and not installed underground.
n. Final Completion: The date when the Engineer confirms in writing that the Contractor has completed the work in accordance with the Construction Documents, including completion of all punch list items, cleanup work and delivery of all required guarantees, warranties, licenses, releases and other required deliverables.
o. Furnish: To purchase, supply, and deliver to the project materials in new and operable condition, ready for installation.
p. Governing Requirements: Collective term for regulations, laws, ordinances, codes, rules, standards, requirements, guidelines, and recommendations that govern the installation and inspection of the work defined in the Contract Documents.
q. Governing Authority: Entities or their representatives charged with formation and/or enforcement of Governing Requirements, such as the Authority Having Jurisdiction (AJH).
r. Install: To place in final position in fully operable, tested condition.
s. Inside Plant (ISP): Infrastructure within a building.
t. Or Equal: Materials approved for use by the Engineer and which are dimensionally suitable and operationally identical to the specified item.
u. Outside Plant (OSP): Infrastructure exterior to a building.
v. Owner: The Owner and the Owner’s designated representative(s).
w. The Project: The total construction of which the Work performed under the Contract Documents may be the whole or a part, and which may include construction by the Owner and/or separate Contractors.
x. Provide: To furnish and install, complete, tested and ready for intended use.
y. Substantial Completion: The date when all work required by the Construction Documents shall be complete (subject to the final punch list to be prepared by the Engineer) and on which the applicable jurisdictional authorities have issued a temporary certification of occupancy.

z. Section: An individual Section of the Specifications.

aa. Shown on Drawings: Noted, indicated, scheduled, detailed, or any other written reference made on the Drawings.


c. Specification Section(s): One or more Sections of the Specifications.

d. Section(s): An abbreviated form of Specification Section(s).

e. The Work: The construction and services required by the Contract Documents, whether completed or partially completed, and all other labor, materials, equipment and services provided or to be provided by the Contractor to fulfill the Contractor’s obligations. The Work may constitute the whole or a part of the Project.

2. Communications Systems

a. Audiovisual System: Includes (but is not limited to) audiovisual cables, connectors, terminations and termination equipment, audiovisual equipment, equipment racks, equipment required for system configuration, programming and testing, and other incidental and miscellaneous product and labor as required.

b. Communications Cabling System: Includes (but is not limited to) communications cables and patch cables, connectors, terminations and termination equipment and panels, equipment racks and distribution equipment, equipment required for the build-out of communications rooms and spaces, and other incidental and miscellaneous product and labor as required.

c. Communications Infrastructure System: A Communications Cabling System in conjunction with a Communications Pathway System.

d. Electrical for Communications Systems

1) Communications Pathway System: Includes (but is not limited to) device boxes, pull boxes, conduit, cable tray, duct/ductbank, and other pathway and raceway components necessary to provide pathway for, support, and route communications cables.

2) Telecommunications Grounding System: Includes (but is not limited to) providing a permanent grounding and bonding infrastructure for the Communications Cabling System.

e. In-Building Wireless System (IWS): Includes (but is not limited to) cabling and equipment used to enhance in-building radio operation by allowing radio frequency signals from outside the building to be re-radiated within the building, and vice-versa.

f. Security System: Includes (but is not limited to) security cables, connectors, terminations and termination equipment, security equipment, equipment racks, equipment required for system configuration, programming and testing, and other incidental and miscellaneous product and labor as required.

g. Structured Cabling System (SCS): Alternative term for Communications Cabling System.

1.7 ABBREVIATIONS

A. Refer to the individual Specification Sections and Drawings for abbreviations and their definitions.
1.8 GOVERNING REQUIREMENTS

A. All work shall be executed in compliance with the applicable portions of the following Governing Requirements:

1. General
   a. ACI: American Concrete Institute (www.aci-int.org)
   b. AHJ: Authority Having Jurisdiction
   c. ANSI: American National Standards Institute (wwwansi.org)
   d. ASTM: American Society for Testing and Materials (www.astm.org)
   e. BELLCORE: Bell Communications Research (www.telecordia.com)
   f. BICSI: A Telecommunications Association (www.bicsi.org)
   g. ETL: Electrical Testing Laboratories
   h. IBC: International Building Code
   i. ICEA: Insulated Cable Engineers Association (www.icea.net)
   j. IEEE: Institute of Electrical and Electronic Engineers (www.ieee.org, www.standards.ieee.org)
   k. IES: Illuminating Engineering Society of North America (www.iesna.org)
   l. FCC: Federal Communications Commission Rules and Regulations
   m. NAB: National Association of Broadcasters
   n. NFPA: National Fire Protection Association (www.nfpa.org)
   q. NEMA: National Electrical Manufacturers Association (www.nema.org)
   r. OSHA: Occupational Safety and Health Administration (www.osha.gov)
   s. RUS: Rural Utilities Service (http://www.usda.gov/rus/)
   t. SMPTE: Society of Motion Picture and Television Engineers
   w. UBC: Uniform Building Code
   x. UFC: Uniform Fire Code (www.nfpa.org)
   z. State and local codes, ordinances, and regulations
   aa. Requirements and guidelines of local utility companies
   bb. Applicable state, local and/or federal laws, regulations, and/or specifications
   cc. Manufacturer installation requirements, guidelines and recommendations

2. Communication System Specific: The following portions of the General Governing Requirements above are particularly relevant to a given Communications System. Omission from this list does not alleviate the Contractor from responsibility for executing all Work for all Communications Systems in compliance with all applicable portions of the Governing Requirements above:

a. Communications Cabling
   1) TIA/EIA 568: Commercial Building Telecommunications Cabling Standard
   2) TIA/EIA 569: Commercial Building Standard for Telecommunication Pathways and Spaces
   3) TIA/EIA 606: The Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
   4) ANSI J-STD-607: Commercial Building Grounding and Bonding Requirements for Telecommunications
   5) TIA/EIA 758: Customer-owned Outside Plant Telecommunications Cabling Standard
   6) ANSI/EIA 310-D: Cabinets, Racks, Panels and Associated Equipment
   7) ANSI/TIA 942: Telecommunications Infrastructure Standard for Data Centers
8) TIA/EIA: Technical Service Bulletins (TSBs) (related to the above TIA/EIA standards)
9) IEEE 802.3 (series): Local Area Network Ethernet Standards
10) BICSI: Customer Owned Outside Plant Design Manual
13) BICSI: Telecommunications Distribution Methods Manual
15) NFPA 70: NEC: National Electrical Code (NFPA Article 70)
16) NFPA 75: Protection of Electronic Computer and Data Processing Equipment
17) NFPA 78: Lightning Protection Code
18) FCC Part 68: Connection of Terminal Equipment to Telephone Network.
19) FCC Part 76.611: CFR Title 47 Radiation Leakage Standards

b. Electrical for Communications:
1) TIA/EIA 569: Commercial Building Standard for Telecommunication Pathways and Spaces
2) TIA/EIA 606: The Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
3) ANSI J-STD-607: Commercial Building Grounding and Bonding Requirements for Telecommunications
4) TIA/EIA 758: Customer-owned Outside Plant Telecommunications Cabling Standard
5) ANSI/TIA 942: Telecommunications Infrastructure Standard for Data Centers
6) TIA/EIA: Technical Service Bulletins (TSBs) (related to the above TIA/EIA standards)
7) BICSI: Customer Owned Outside Plant Design Manual
8) BICSI: Telecommunications Cabling Installation Manual
9) BICSI: Telecommunications Distribution Methods Manual
10) NFPA 70: NEC: National Electrical Code (NFPA Article 70)
11) NFPA 75: Protection of Electronic Computer and Data Processing Equipment
12) NFPA 78: Lightning Protection Code
13) UL 467: Grounding and Bonding Equipment

c. Audiovisual:
1) IEEE C62.41: Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits
2) NAB: National Association of Broadcasters
3) UL 1449: Transient Voltage Surge Suppressors
4) SMPTE: Society of Motion Picture and Television Engineers
5) Sound Systems Engineering, 2nd Ed. Davis and Davis, Howard W. Sams Co., 1987

3. Owner Specific: The Contractor shall comply with the following Owner requirements. These requirements shall be incorporated by reference into these Specifications and shall be hereinafter considered a Governing Requirement:
a. University of Colorado at Boulder:
1) UCB Telecommunications Standards:
(http://www.colorado.edu/facilitiesmanagement/pdc/construction/standards/documents/Division27CommunicationsSpecifications.pdf)
a) Work shall be executed and inspected in compliance with the UCB Telecommunications Standards (available at above hyperlink or through UCB ITS), including, but not limited to:
   i. UCB Division 27 Telecommunications Standards
   ii. UCB Construction Drawings As-built Requirements
   iii. UCB Cable Footage and Count Information
   iv. UCB Construction Inspection Report
   v. UCB Approved Rack Details
   vi. UCB ITS Telecom CAD Standards Guidelines
vii. UCB Labeling and Testing Document  
viii. UCB Jack Numbering Document (T-5)  
ix. UCB Wireless Ceiling and Wall Security Box Instructions  
x. UCB Typical Telecommunications Conduit Layouts Drawing  
  b) UCB Safety Requirements  
c) These Specifications may expand upon or supplement the UCB Telecommunications Standards.  
i. For bidding purposes, in the event of a conflict or discrepancy between these Specifications and the UCB Telecommunications Standards, the UCB Telecommunications Standards shall govern. However, if the requirement of these Specifications (or portion thereof) exceeds that of the UCB Telecommunications Standards, and is furthermore not contrary to the UCB Telecommunications Standards, then the requirement of these Specifications (or portion thereof) shall prevail.  
ii. For installation purposes, in the event of a conflict or discrepancy between these Specifications and the UCB Telecommunications Standards, the Contractor shall notify the Engineer and await approval to proceed.

B. Nothing in the Governing Requirements and Construction Documents shall be construed to permit work not conforming to all governing codes and regulations.

C. Errors or omissions in the Construction Documents do not relieve the Contractor from executing the work in accordance with the Governing Requirements, including all governing codes and regulations.

D. The applicable portions of the Governing Requirements shall be incorporated by reference into each related Specification Section in this Division.

1.9 PERMITS AND FEES
   A. The Contractor shall obtain and pay for all licenses, permits and inspections required by the laws, ordinances and rules governing work specified herein. Such fees shall be included in the bid amount.
   B. The Contractor shall pay all fees, including but not limited to fees for local utility service installation, connection charges, etc. Such fees shall be included in the bid amount.
   C. Notations on permit or review documents shall be observed. Additional requirements noted by the Governing Authority shall be made part of the requirements for construction of the Project. Additional costs for implementing these requirements, if any, shall be submitted for review prior to construction.
   D. Engineering Fees: The Specifications may identify work required of the Engineer due to improper action(s), lack of action(s), and/or deficiencies on the Contractor’s part. Such instances will be identified in the Specifications and the Contractor shall be responsible for these fees if they are incurred by the Engineer.
      1. Fees charged to the Contractor will be at the Engineer’s billing rates at the time the services are performed. Travel time will be included, if applicable. Mileage will be charged for required automobile travel at the standard IRS mileage rate in effect at the time the services were performed. Expenses will be billed at cost plus 10 percent markup.
      2. Fees will either be paid directly to the Engineer or will be deducted directly from payments (or the final payment) to the Contractor.
1.10 SUBSTITUTIONS AND DEVIATIONS

A. The requirements below expand upon and/or supplement the requirements in Division 1.

B. Substitution of product and deviations from the methods of construction specified which are used in the Contractor’s bid shall be at the sole risk of the Contractor, and as such are subject to rejection without consideration.

C. Proposed substitution and deviation requests shall be reviewed during the time of Submittal review:

   1. Conditions for Consideration: Substitution and deviation requests will be received and considered only when one or more of the following conditions are satisfied:
      a. A substantial advantage is offered to the Owner, in terms of cost, time, or other considerations of merit.
      b. The specified product or method of construction cannot be provided with the contract period.
      c. The specified product or method of construction cannot receive necessary approval by a Governing Authority, and the requested substitution can be approved.
      d. The specified product or method of construction cannot be provided in a manner that is compatible with other materials.
      e. The product as specified includes the statement, “Or Equal.”

   2. Conditions for Rejection: Substitution and deviation requests will be rejected for the following reasons, among others:
      a. The conditions for consideration (see above) have not been met.
      b. Extensive revisions to the Construction Documents are required to support the proposed changes.
      c. The proposed changes do not comply with the general intent of the Construction Documents.
      d. The substitution request is for product which does not include the statement, “Or Equal”, or is specified as “no substitute”, “substitutions are not acceptable”, “provide as specified” or similar.
      e. The proposed change is solely for the convenience or economic gain of the Contractor.

D. The Contractor shall not proceed with a substitution or deviation without written approval.

   1. Upon approval of the request, the Contractor shall be responsible for fees incurred by the Engineer for re-design work or modifications to the Construction Documents if necessitated by the nature of the request.

1.11 SUBMITTALS

A. The requirements below expand upon and/or supplement the requirements in Division 1.

B. General:

   1. Submittal review is a courtesy extended to the Contractor for the limited purpose of checking for general conformance with the design concept and the information shown in the Construction Documents.
   2. The Contractor shall provide submittal information as soon as practicable after the date of Notice to Proceed and prior to the purchase, delivery, fabrication, and installation of product and materials.
   3. In the event of discrepancies or conflict between Submittals and the Construction Documents, either prior to or after review, the requirements of the Construction Documents shall prevail.
   4. Submission of material for review, regardless of the outcome of the review, does not alter the Contractor’s obligation to follow the intent of the Construction Documents, nor the Contractor’s responsibility to comply with the Construction Documents.
5. Submittals will not be reviewed and will be returned to the Contractor without review for the following reasons:
   a. Submittal package does not conform to the requirements listed herein.
   b. Submittal is for a product or method of construction not required by the Construction Documents.
   c. Submittal is partial or incomplete.
   d. Submittal contains information concerning the proposed implementation of means, methods, procedures, sequences or techniques, temporary aspects of the construction process, or other items, which are the sole responsibility of the Contractor.
   e. Submittal was not carefully reviewed by the Contractor prior to submission, as evidenced by poor organization, obvious or numerous errors, lack of correlation or cross-referencing, lack of clarity in presentation, or containing Shop Drawings which do not meet the standard of the Construction Drawings.
   f. Submittal was submitted directly from the Contractor’s subcontractor(s) or vendor(s).
   g. Subcontractor and/or vendor submittal information was not carefully reviewed and/or approved by the Contractor.
   h. Submittal does not bear the Contractor’s approval stamp, and/or contains subcontractor and/or vendor submittal information which does not bear the Contractor’s approval stamp.
   i. Submittal contains substitution and/or deviation requests, which are not clearly identified as substitution or deviation requests in a separate “Substitution and Deviation Requests” section of the Submittal.

6. Submittals shall be submitted as a single package and shall include subcontractor and vendor submittal information.

7. Each submittal (or re-submittal) set shall bear a unique Contractor’s submittal sequence number.

8. Requests for substitution shall only be included under the “Substitution and Deviation Requests” section of the submittal (see below) and shall comply with the requirements of Part 1 – General: Substitutions and Deviations herein. Submission of substitution requests in any other portion of the Submittal does not constitute an acceptable or valid request for substitution, nor will review of such information constitute approval in any manner.

C. Submittal Format:
   1. Submittals shall be bound in one letter-sized (8-1/2 inch by 11 inch) document and under separate cover from submittals furnished under other Divisions.
   2. Front cover of Submittal shall indicate the name of the project, the project number, the name of the Owner, year of completion, the title “Telecommunications Submittals”, and the names of the Engineer and Contractor, as well as the General Contractor.
   3. Submittals shall include a table of contents identifying sections, Specification Sections, and page numbers.
   4. Information provided in the submittal shall follow the same general order of the Specifications.
   5. Submittals shall be sectionalized (Indexed with titled tab dividers (by section name – not numbered and not handwritten)).
      a. Sections shall be (see Submittal Sections below for more detail regarding each section):
         1) Product Data
         2) Shop Drawings
         3) Samples
         4) Substitution and Deviation Requests
         5) Test Reports
         6) Other Information
      b. Within each section, information shall be organized by Specification Section and/or Drawing to which the information applies.
c. Within each section, where section is not applicable (e.g. shop drawings, technical drawings, etc.), the section shall include a page denoting same.
6. Pages shall be numbered.
7. Drawings (except for full and half-size Shop Drawings), if not in 8-1/2 inch by 11 inch size, shall be bound and accordion folded to 8-1/2 inch by 11 inch size.
8. Quantity: Submit copies in quantities per the requirements of Division 1.

D. Submittal Sections: Submittals shall be sectionalized and shall include sections for Product Data, Shop Drawings, Substitution and Deviation Requests, and Samples, Other Information (see Submittal Format herein).
1. Product Data: Submit Product Data information as called for in the individual Specification Sections. Product Data shall include:
   a. For product which is being provided as specified, do not provide product data. Instead, provide a list of all products to be provided as specified and state in writing that each product in the list is being provided as specified.
   b. For all other product other than that specified, provide the following product information (as applicable):
      1) Specification Section to which the product applies.
      2) Catalog cut sheets, manufacturer data sheets, and/or specification sheets detailing the product, item, assembly and installation.
      3) Manufacturer’s printed recommendations (if not included in the above).
      4) Written description.
      5) Notation of dimensions verified by field measurement.
      6) Notation of coordination requirements.
      7) Compliance with recognized trade association and testing agency standards.
      8) Highlighted details within the product data that identifies compliance with the Construction Documents or the intent of the Construction Documents.
      9) Highlighted details within the product data that identifies deviations from the Construction Documents or the intent of the Construction Documents.
   c. For products for which the Contractor is proposing a substitution, include the product as specified in the Submittal per the above requirements and list the reference to the proposed substitution in the “Substitution and Deviation Requests” section of the Submittal (see below).
   d. Do not provide product quantities – quantities are the sole responsibility of the Contractor and will not be reviewed.
2. Shop Drawings: Submit Shop Drawings that are newly prepared, drawn to accurate scale, and that fully illustrate the Contractor’s understanding of the intent and requirements of the Construction Documents (i.e. Shop Drawings shall not be based upon or consist of a reproduction of the Construction Documents or standard printed data). Submit Shop Drawings as called for in the individual Specification Sections. Shop Drawings shall include:
   a. Identification of products and materials
   b. Schedules, including but not limited to:
      1) Equipment and components
      2) Cables: identify manufacturer, model number, outside diameter and connector
   c. Notation of coordination requirements
   d. Notation of dimensions established by field measurement
   e. Notation of details that identify compliance with the Governing Requirements
   f. Notation of details that identify compliance with the Construction Documents or the intent of the Construction Documents.
   g. Notation of deviations from the Construction Documents or the intent of the Construction Documents. Highlight, encircle, or otherwise clearly indicate such deviations
   h. Roughing-in and setting diagrams
Basic Communications Requirements

i. Fabrication, installation, and adaptation details including, but not limited to:
   1) Electronic equipment to be mounted within racks
   2) Cable routing between electronic equipment in racks or housings
   3) Equipment to be mounted within furniture
   4) Wall and ceiling mounted devices
   5) System labels, including but not limited to engraved, lamacoid, silk screen and paper labels
   6) Suspended loudspeaker mounting, including but not limited to tilt angle, splay angle, height above finished floor, coverage pattern, and assembled weight
   7) Non-standard manufactured or adapted equipment
   8) Dimensions
   9) Other details as necessary to establish the intent of the Construction Documents

j. One-line diagrams detailing the interconnections of system components, including the identification of all devices, cabling, terminations, and termination techniques as required for fully functional systems

k. Applicable software block diagrams representing the internal operation of devices such as, but not limited to, control processors and digital signal processors

l. Templates

m. Floor plans identifying equipment locations, if not shown on the Construction Documents

n. Reflected ceiling plans identifying equipment locations, if not shown on the Construction Documents

o. Indication of sectionalized manufacturing of equipment (i.e. for oversized equipment that cannot be installed as a single component).

p. Shop drawings shall be provided in form, format and size identical to that of the Construction Drawings (the Construction Drawings set the standard). Shop Drawings that do not meet this standard shall be rejected without review.
   1) Title Block: May be the Contractor’s Title Block, but shall indicate Project name, manufacturer’s name and logo, date of submittal, content of sheet, and sheet number.
   2) Floor Plans: Plan titles, scales, north arrows, column lines, line types, fonts, and room names and numbers shall match that of the Construction Drawings.

q. For methods of construction for which the Contractor is proposing a deviation, include the method of construction as specified per the above requirements and list the reference to the proposed deviation in the “Substitution and Deviation Requests” section of the Submittal (see below).

3. Substitution and Deviation Requests: For each substitution and/or deviation request, include the following:
   a. Whether the request is for substitution of product or a deviation from a construction method.
   b. The Specification Section(s) or Drawing to which the request applies.
   c. Reason for the request. (Note: the reason must conform to the requirements of Part 1 – General: Substitutions and Deviations herein.)
   d. If a substitution, provide:
      1) Specified product to which the proposed substitution applies.
      2) Product Data for the substituted product.
      3) Notation of differences between the proposed substitution and the specified item. Highlight, encircle, or otherwise clearly indicate the substitution.
   e. If a deviation, provide:
      1) Specified Drawing and/or method of construction to which the proposed deviation applies.
      2) Shop Drawings showing the deviation.
3) Notation of differences between the proposed deviation and the specified drawing and/or construction method. *Highlight, encircle, or otherwise clearly indicate the deviation.*

f. Written statement signed by the Contractor stating that the proposed substitution or deviation is equivalent or superior in function, appearance, and quality to the specified product or construction method and that the proposed substitution or deviation will be at no additional cost to the Owner.

4. Samples: Submit Samples as called for in the individual Specification Sections.
   a. Samples shall be indexed in this section and provided as an attachment to the Submittal.

5. Test Reports:
   a. Submit full-size mock-ups of the test reports that will be used to document the testing.

6. Other Information:
   a. Contractor Statement of Qualifications, per Division 27 Specification Section *Contractor Qualifications.*
   b. Bid Form or Bid Supplement Form, per Division 27 Specification Section *Bidding.*
   c. Owner Specific: Submit other information as required by Owner Specific Governing Requirements.
   d. Submit additional information as called for in the individual Specification Sections.

E. Submittal review:
1. The submittal review will not include review of the accuracy or completeness of details, such as quantities, dimensions, weights or gauges, fabrication processes, construction means or methods, coordination of work with other trades, or construction safety precautions, all of which are the sole responsibility of the Contractor.

2. Corrections or comments made on the Submittal by the reviewer during the submittal review do not relieve the Contractor from compliance with the requirements of the Construction Documents.

3. Review of a specific item shall not indicate that the reviewer has reviewed the entire assembly of which the item is a component.

4. Review does not relieve the Contractor from responsibility for errors, which may exist in the submitted data.

5. Review of substitutions and deviations:
   a. The reviewer shall not be responsible for review of substitutions and/or deviations that were not brought to the attention of the reviewer by specific inclusion of the substitution and/or deviation in the Substitution and Deviation Requests section of the Submittal.
   b. Where a substitution and/or deviation is not included in the Substitution and Deviation Requests section of the Submittal, the procurement and installation of the substitution and/or deviation is at the sole risk of the Contractor.
   c. If the reviewer does not specifically note substitutions and/or deviations, it remains the Contractor’s responsibility to comply with the Construction Documents.

6. After review, submittals shall be returned together with review comments and specific actions (if required) to be taken by the Contractor. Typical comments and actions will be:
   a. No Exception Taken
   b. Revise - Resubmittal Required
   c. Revise - Resubmittal Not Required
   d. Submit Specified Item
   e. Rejected
   f. Not Reviewed

7. The Contractor shall perform no portion of the Work requiring a submittal until the respective submittal has been reviewed and approved. Such Work shall be in accordance with the approved submittal.
F. Re-submission of submittals:
1. Submittals shall continue to be re-submitted and reviewed until all submitted items are marked by the Engineer as ‘No Exceptions Taken’ or ‘Revise - Re-submittal Not Required’.
2. Re-submittals shall be clearly identified as a re-submittal and shall identify changes on a separate Revisions page inserted after the Table of Contents page(s).
3. The Contractor shall be responsible for fees incurred by the Engineer resulting from subsequent review of re-submittals that fail to meet the requirements herein. Such fees will be incurred after the Engineer has reviewed the original submission and one re-submission.
4. Re-submittals do not entitle the Contractor to additional time, nor are they considered cause for delay of the project.

1.12 RECORD DOCUMENTS

A. The requirements below expand upon and/or supplement the requirements in Division 1.

B. The Contractor shall maintain a set of Record Documents showing all additions, changes, and deletions that have been made to the original Drawings and Specifications throughout the course of construction, as well as reviewed Submittal data, including but not limited to Shop Drawings.
1. Items to be noted shall include but shall not be limited to:
   a. Final device box, pull box, floor box, sleeve and conduit stub/ poke thru locations
   b. Final locations, sizes, and dimensions of equipment, including concealed equipment
   c. Routing of concealed raceways/pathways
   d. Raceways/pathways located more than 2 feet from where shown on the original Construction Documents
   e. Raceways and main pathways (pathways with more than 30 cables) not shown on the Drawings
   f. Building outline changes
   g. Addenda, accepted Alternates, Change Orders, other document revisions which occurred after the award of the Contract and/or the start of construction activities
   h. System component labels and identifiers for all major components
   i. Shop Drawings, including those submitted for approval and those used for construction but not required for submission.
2. Notations shall be in a neat, legible and logical manner. Areas affected by the change shall be clouded.

C. Record Documents shall:
1. Be kept current (i.e. no more than one week behind actual construction) throughout the course of construction.
2. Be retained at the job site until Final Acceptance.
3. Be made readily available at all times to the Owner’s representative.
4. Not be the Contractor’s working documents.
5. Be protected from deterioration and loss in a secure, fire-resistant location.
6. Be made readily available to the Engineer for review of completeness and accuracy throughout the course of construction.
7. At project closeout, be updated with the items on the Known Exceptions/Deviations List per the requirements of Part 3 – Execution: Project Close-Out, herein. Include only those items marked “Approved” by the Engineer.

1. Handwritten notations on the Record Drawings shall be CAD drafted by the Contractor onto a final, fresh set of Construction Drawings prior to submission. Record Drawings shall be provided in form, format, size, and CAD version identical to that of the Construction Drawings (the Construction Drawings set the standard). Record Drawings that do not meet this standard shall be rejected without review.
2. The Record Drawings shall be reviewed by the Contractor for accuracy and completeness prior to submission.

E. Owner Specific:
1. Record Drawings shall be reformatted by Contractor to fully conform to UCB ITS Telecom CAD Standards for Documentation and Construction Projects.
2. Submit other information as required by Owner Specific Governing Requirements.

F. Submit additional information as called for in the individual Specification Sections.

1.13 OPERATING AND MAINTENANCE (O&M) MANUALS

A. General:
1. O&M Manuals shall be submitted in accordance with the applicable portions of Division 1.
2. O&M Manuals shall be submitted as a single package and shall include subcontractor and vendor O&M information.
3. O&M Manuals shall be prepared by personnel who are:
   a. Completely familiar with the requirements of this Section
   b. Trained and experienced in the maintenance and operation of the described products
   c. Skilled as a technical writer to the extent required to communicate essential data
   d. Skilled as a draftsperson competent to prepare the necessary Drawings
4. Catalog pages and data included in O&M Manuals shall be originals. Where not possible to obtain original copies in sufficient quantity, catalog pages and data shall be neat, clean copies of the originals.
5. O&M Manuals shall include the following:
   a. Table of Contents
   b. Operations: Assemble operations and instructions data which shall include all procedures necessary for activating and controlling each system and/or component in all modes of operation and for fulfilling all functional requirements.
   c. Product Data: Include the product data provided in the original Submittal(s) reflecting product as supplied and installed, as well as additional information such as manufacturer, installation, operation, routine maintenance information, and technical specifications.
   d. Shop Drawings: Include the Shop Drawings provided in the original Submittal(s) reflecting the system and/or components as installed.
   e. Service Information: Assemble service information (cleaning, adjustments, frequency, etc.) for each device requiring service. For devices requiring qualified service, compile an index of qualified service providers (and their contact information) able to service these devices. Provide a recommended maintenance schedule for each device.
   f. Spare Parts: Assemble a list of spare parts. Compile an index of spare parts providers (and their contact information) able to provide the spare parts.
   g. Tests Results: Assemble all test documentation made for each system, device, and/or component requiring testing.
   h. Calibration/Configuration Settings: Assemble and document all calibration/configuration settings made for each system, device and/or component requiring calibration and/or configuration. Include ‘normal’ settings for each component.
   i. Record Documents: Provide Record Documents per the requirements of Part 1 – General: Record Documents herein.
   j. Final punchlist: Provide the final punchlist including all corrective action taken and Contractor initials per the requirements of Part 3 – Execution: Project Close-Out.
   k. Certificates of Inspection: Provide certificates of inspection and final approval from all applicable Governing Authorities, the Manufacturer(s), the Contractor’s RCDD, etc.
   l. Warranty: Provide warranty documentation per the requirements of Division 27 Specification Section Warranty and the individual Specification Sections.
m. Software, including but not limited to:
   1) All source code for custom programs. Source code shall be provided on CD-ROM.
   2) System software
   3) Computer system operating software
   4) Application software
   5) Version Documentation: Provide a spreadsheet in MS Excel format documenting all
      software and firmware versions for all programmable devices. Provide in both
      printed format and on CD-ROM.

n. Other Information:
   1) Submit additional information as called for in the individual Specification Sections.
   2) Owner Specific: Submit other information as required by Owner Specific Governing
      Requirements.

6. O&M Manual contents shall also be submitted in both hard copy and soft copy on CD-ROM.

B. O&M Manual format:
   1. O&M Manuals shall be bound in one letter-sized (8-1/2 inch by 11 inch) hard cover (hard
      back or loose leaf) binder.
   2. Separate O&M Manuals shall be provided for each communications system (i.e.
      Communications Cabling, Audiovisual, Security, etc.)
   3. Front cover of the O&M Manual shall indicate the name of the project, the project number,
      the name of the Owner, the title of the O&M Manual indicating the communications system
      (Communications Cabling System O&M Manual, Audiovisual System O&M Manual,
      Security System O&M Manual, etc.), the year of completion, the name of the Engineer, the
      name of the Contractor, and as applicable the names of the Architect and the General
      Contractor.
   4. Side cover of the O&M Manual shall indicate the name of the project, the project number,
      the name of the Owner, and the title of the O&M Manual.
   5. O&M Manual shall include each section defined under O&M Manual Requirements above.
   6. O&M Manuals shall include tab dividers, titled (not numbered) for each section. Tab
      dividers shall not be handwritten.
   7. O&M Manuals shall include a table of contents identifying sections and page numbers.
   8. Pages within each section shall be numbered.
   9. Drawings (excluding full size Record Drawings) shall be bound and accordion folded to 8-1/2
      inch by 11 inch size.

C. O&M Manual submission:
   1. The Contractor shall submit one draft copy of the O&M Manual for review and approval by
      the Engineer.
      a. The submission will be reviewed for accuracy, completeness, and compliance to the
         requirements herein. A submission which fails to meet these requirements will be
         rejected and returned to the Contractor together with review comments and specific
         actions to be taken by the Contractor. The Contractor shall revise the O&M Manual and
         re-submit for review and approval.
      b. The O&M Manual shall continue to be re-submitted and reviewed until such time as the
         O&M Manual is approved by the Engineer.
      c. The Contractor shall be responsible for fees incurred by the Engineer resulting from
         subsequent review of O&M Manuals that fail to meet the requirements herein. Such fees
         will be incurred after the Engineer has reviewed the original submission and one re-
         submission.
   2. Upon approval of the draft copy, the Contractor shall submit final copies in quantities per the
      requirements of Division 1

D. Final payment to the Contractor will not be authorized until the final copies of the O&M
   Manuals (including Record Documents) have been received and approved by the Engineer.
PART 2 - MATERIALS

2.1 GENERAL

A. Where one or more products are listed for a specified component:
   1. The product listed first shall establish size, capacity, grade, quality, technical specifications, and the basis of design.
   2. Products not listed first shall be considered “other acceptable” products. Should the Contractor choose to use those products, costs for changes to the construction required to support the use of these products shall be borne by the Contractor.

B. If no product is listed, then any manufacturer able to meet the listed Specifications is acceptable.

C. Where product is specified without the statement “or equal”, substitutions will not be entertained.

2.2 MATERIALS

A. The Contractor is responsible for providing all incidental and/or miscellaneous tools, scaffolding, consumable items, testing equipment appliances, and other hardware not explicitly specified or shown on the Drawings required for the installation of a complete and operable systems ready for the Owner’s use.

B. Products shall be:
   1. New and unused, free from blemish and defects.
   2. Standard products of manufacturers regularly engaged in the production of such products.
   3. Of the manufacturers latest standard design at the time of procurement,
   4. Designed to ensure satisfactory operation and life in the environmental conditions that prevail in their installation location.
   5. Designed for application in commercial/professional systems, except as otherwise specifically noted.

C. All products, whether stock or custom, shall be supported by replacement parts and manufacturer schematic drawings as applicable. “Black box” and/or unidentified components are not acceptable.

D. All products of the same or similar type shall be the product of one manufacturer.

E. All component products within a unified system shall be the product of one manufacturer.

F. Equipment shall be UL listed, or equivalent.

2.3 DELIVERY, STORAGE, AND HANDLING

A. Prior to ordering and delivery of equipment, the Contractor shall:
   1. Verify that the equipment shall adequately pass through building openings and passageways with unobstructed access to the final equipment location. When building openings and passageways will not permit the equipment to pass through unobstructed, equipment shall be manufactured and shipped in sections for final assembly at the equipment location.
   2. Verify that the equipment shall properly fit the space allocated, that required clearances can be maintained, and that the equipment can be located without interference from other systems, structural elements, or the work of other trades.

B. The Contractor shall arrange deliveries in accordance with the construction schedule. Deliveries shall be scheduled to maintain the progress of work, to avoid conflict with the work of other Trades, and to accommodate site conditions.
   1. The Contractor shall be responsible for coordinating and scheduling the timely delivery of products and materials indicated to be furnished by others or by the Owner.
C. Deliver, store and handle products and materials in full compliance with the manufacturer’s recommendations and/or instructions, using means and methods that will prevent damage, deterioration, and loss (including theft).

D. The Contractor shall protect products and materials until Final Acceptance. Such protection is the sole responsibility of the Contractor, and the Contractor shall be responsible for replacing damaged, deteriorated, stolen or lost product at no additional cost to the Owner.
   1. Where products and materials are indicated to be furnished by others or by the Owner, the Contractor shall make a complete and careful check of all materials delivered. The Contractor shall provide a written and signed receipt acknowledging acceptance of the delivery and the condition of the materials delivered. After receipt, the Contractor shall assume full responsibility for the materials.

E. Products and materials subject to damage by the elements shall be stored above ground, under cover, in a weather tight enclosure, with ventilation adequate to prevent condensation. Temperature and humidity shall be maintained within the manufacturer’s recommendations.

F. The Contractor shall make provisions for receiving and storing products and materials, including products and materials to be furnished by the Owner (or by others) to be installed by the Contractor as part of the work.

G. Products and materials shall be carefully inspected for damage upon delivery. Defective or damaged products and materials shall be marked ‘Rejected’, removed from the site, and shall not be installed.

H. Products and materials shall be delivered to the site in the manufacturer’s original containers, complete with labels and instructions for the proper handling, storage, unpacking, protection and installation.

I. The Contractor shall ensure that products and materials to be installed are not temporarily used as steps, ladders, platforms, scaffolds, or for storage by the Contractor or by other trades during the construction process. Materials found to be used in such a manner will be considered “damaged”, shall not be installed, and shall be replaced at no additional cost to the Owner.

### PART 3 - EXECUTION

#### 3.1 GENERAL

A. Work shall comply with the applicable portions of the Governing Requirements in effect at the time of construction, including all addenda, errata, annexes, and technical service bulletins (TSBs), etc., except where a specific date, version, or edition is otherwise indicated, or where otherwise mandated by a Governing Authority.

B. In the event of a conflict between a code and the other Governing Requirements, or between a code and a requirement of the Construction Documents, the code requirement shall govern. However, if the non-code requirement (or portion thereof) exceeds that of the code, and is furthermore not contrary to the code, the non-code requirement (or portion thereof) shall prevail.

C. Installation shall be performed by workers skilled in the trade, familiar with the particular techniques and methods of construction applicable to the work of the trade.

D. Completed work shall present a neat and professionally installed appearance. The appearance of the work shall be of equal importance to its operation. Failure to present a neat and professionally installed appearance shall be considered sufficient reason for rejection of the system in part or in whole.
E. Completed work shall demonstrate quality workmanship. Quality workmanship shall be of equal importance to its operation. Failure to demonstrate quality workmanship shall be considered sufficient reason for rejection of the system in part or in whole.

F. In the event that supplemental information is required to confirm the intent of the Construction Documents, the Contractor shall notify the Engineer and await the Engineer’s response prior to procurement of materials and performance of the related work. Procurement of materials and work performed without such interpretation and/or clarification is at the sole risk of the Contractor, and as such, the Contractor shall correct such work at no additional cost to the Owner should the materials or work not conform to the intent of the Construction Documents.

G. The Contractor shall order and install materials and equipment with long lead times and/or those having a major impact on work by other trades so as not to jeopardize the project or project schedule.

H. The Contractor is responsible for ensuring that each installed component’s performance is within the Manufacturer’s published specifications, the Governing Requirements, and all other requirements as specified within this Division.

I. The Contractor is solely responsible for the safety of the public and workers in accordance with all applicable rules, regulations, building codes and ordinances, and Governing Requirements, including but not limited to employee training and Safety Program development, documentation and execution.

J. Notwithstanding any other provisions of the Contract Documents, the Contractor shall be solely responsible for location and protecting any and all utility service lines (both Owner controlled and Public) in the work area.

3.2 IDENTIFICATION

A. All Contractor personnel shall be clearly identified by uniform and/or company badge with photo ID, employee’s name, and company name. Contractor vehicles shall be equipped with signs on both sides of vehicle identifying the Contractor’s company name.

B. The Contractor may also be issued and required to wear Owner provided Contractor ID’s for the duration of the project (coordinate this requirement with the Owner prior to any on site work). Such identification will be for the purposes of entry into card access controlled locations and/or identification of authorized Contractor personnel. All Owner provided Contractor ID’s shall be returned to the Owner prior Final Acceptance. The Work will not be considered complete until all ID’s are returned.

3.3 SUPERVISION

A. The Contractor shall appoint a Project Manager who will be the single point of contact for all work accomplished under this Project and will be vested by the Contractor with the authority to make decisions on behalf of the Contractor.

1. The Project Manager will be responsible to represent the Contractor and coordinate all aspects of this Project, including but not limited to:
   a. Overall and specific project responsibility
   b. Thorough knowledge of Project Specifications and Drawings
   c. Creation and maintenance of a project schedule, including milestones, task definitions and resource allocations
   d. Attendance at all Project Management meetings
   e. Supervision and direction of all Contractor personnel
   f. Documentation, including submittals and change orders
   g. Quality assurance of Project
2. The Project Manager initially assigned to the Project shall be assigned to the Project for the duration of the Project. Once assigned by the Contractor, the Project Manager shall not be changed by the Contractor without Engineer and Owner approval.

B. The Contractor shall assign a qualified Foreman to the Project and shall keep the Foreman on site and in charge of the work at all times. The Foreman shall be equipped with a mobile phone during project working hours.
   1. The Foreman initially assigned to the Project shall be assigned to the Project for the duration of the Project. Once assigned by the Contractor, the Foreman shall not be changed by the Contractor without Engineer and Owner approval.

3.4 PERMITS AND FEES
A. The Contractor shall make arrangements to obtain and pay for necessary permits, licenses, and inspections.

B. No work shall be started prior to obtaining necessary permits and payment of required fees. Work installed prior to obtaining proper permits shall, if required by the Governing Authority (AHJ), be redone in compliance with requirements at no additional cost to the Owner.

3.5 INSTALLATION
A. The Contractor shall notify the Engineer and wait for direction/instruction prior to proceeding with procurement and installation for any portion of the Work which could be affected by the following:
   1. Required items and/or details have been omitted from the Construction Documents.
   2. Discrepancies or conflicts exist between the requirements of the Drawings and the Specifications, between the Governing Requirements and the Construction Documents, and/or between the various Governing Requirements.
   3. Discrepancies or conflicts between the requirements of this Division and those of Division 1.

B. Dimensions and clearances:
   1. Equipment dimensions and dimensions indicated for the installation of equipment are restrictive dimensions. Verify that the equipment will fit within the indicated locations and spaces.
   2. Maintain, at a minimum, code required clearances.
   3. Promptly notify the Engineer of any potential dimension or clearance conflicts, and await the Engineer’s direction prior to purchase and rough-in of the equipment.

C. Access:
   1. Install equipment such that it is readily accessible for operation and maintenance.
   2. Access to equipment shall not be blocked or concealed by conduits, supporting devices, boxes, or other items.
   3. Do not install equipment such that it interferes with the normal operation or maintenance requirements of other equipment.

D. Equipment shall be installed level, plumb, parallel, and perpendicular to building structures and to other building systems and components, except where otherwise indicated.

E. Equipment shall be securely fastened. Select fasteners so that the load applied to any one fastener does not exceed 25 percent of the proof-test load.

F. Place equipment labels and/or other identification where the label and/or identification can be easily seen and read without difficulty.

G. Grounding/Bonding: Bond all non-current carrying raceway to the nearest TGB. Ground connections for conduit shall be exothermic weld.
H. Attachment of hanger rods, support cables, diagonal wall bracing, and any other connections made to the building structure after the application of fireproofing/firestopping materials, shall be made with minimal impact to the fireproofing/firestopping materials. The Contractor making such connections shall remove only as much fireproofing/firestopping as required for the attachment, and for scoring and over-cut only as required for the connection. The Contractor shall be held responsible for costs associated with patching of excessively removed fireproofing/firestopping material.

I. Cables, conduits, and other raceway shall be firmly secured and cleaned where penetrating fire rated barriers.

3.6 DRAWINGS

A. Drawings shall not be scaled for rough-in measurements or equipment locations. Field verification of dimensions, locations, and levels to suit field conditions is required. Final placement of devices, outlets, equipment, etc. shall be coordinated with field conditions.

B. Unless specifically dimensioned or detailed, Drawings indicate approximate locations, arrangement, and general character. To avoid interference with structural members and equipment of other trades, or for the convenience of the Owner, it may be necessary to adjust the locations shown on the Drawings prior to installation. Unless specifically dimensioned or detailed, and with the exception of locations of equipment and raceway in specialized communications rooms and spaces (such as Telecommunications Rooms, Data Centers, etc.), the Contractor may make minor location adjustments without obtaining the Engineer’s prior approval. All other adjustments require prior approval from the Engineer.

1. Minor adjustments are defined as distances not to exceed:
   a. 1 foot at grade, floor ceiling, and roof level in any direction in the horizontal plane
   b. 1 foot on walls in a horizontal direction within the vertical plane.

2. Particular attention shall be paid to door swings, piping, ductwork, structural steel, and other ceiling conflicts:
   a. In general, waste and vent lines, large pipe mains, and ductwork shall be given priority for the locations and spaces shown.
   b. In general, electrical lighting fixtures shall be given priority for ceiling space.

3. Where minor location adjustments are required, such adjustments shall be made at no additional cost to the Owner.

3.7 ASBESTOS/LEAD

A. The Owner manages asbestos/lead identification, removal and control. Normally the site of work operations will be identified by the Owner as suitable for construction to proceed and Owner EH&S documentation is provided for the Contractor to file. The Contractor shall refer to and comply with the EH&S report from UCB prior to performing any work. If that documentation is not available, the Contractor shall not proceed with the work until that documentation is available.

B. The Contractor shall be aware of and comply with Owner specific procedures and policies related to asbestos and lead (contact EH&S at 303-492-02165).

C. The Owner requires appropriate asbestos awareness training of Contractor employees. This training shall be provided to Contractor employees at no additional cost to the Owner.
D. In the event the Contractor encounters suspected asbestos/lead containing materials which have not been rendered harmless, the Contractor shall immediately stop work in the area affected and report the condition to the Owner verbally followed by written notice. If in fact the material contains asbestos/lead and has not been rendered harmless, the work in the affected area shall not be resumed except by written agreement between the Owner and the Contractor. In the absence of asbestos/lead, or after it has been rendered harmless, work shall be resumed by written agreement between the Owner and the Contractor.

3.8 RESTORATION

A. The Contractor shall restore all floors, ceilings, walls, furniture, grounds, pavement, etc. affected or damaged by the Contractor’s work. All such areas shall be restored to original condition at no additional cost to the Owner.

B. The Contractor shall restore to original finish all new products, materials, and equipment scratched, chipped, or otherwise marred by the Contractor.

C. Restoration in every instance consists of completing the work to match and blend with the adjoining existing work insofar as methods, materials, colors, and workmanship are concerned.

D. Restoration work shall be performed by workers qualified and skilled in the trades involved.

E. Where restoration work requires painting: Painting shall consist of cleaning, surface preparation, painting (primer, intermediate, and finish) and finishing surfaces, for items both new and existing, affected by the work of the Contractor. Surface painting shall match and blend with existing adjoining surfaces. The areas around penetrations, once sealed, shall be painted.

F. The Contractor shall be responsible for replacing improperly matched, blended, or poorly constructed restorative work at no additional cost to the Owner.

3.9 HOUSEKEEPING

A. During the course of construction:
   1. The Contractor shall keep the building, premises and surrounding area free from accumulated surplus, waste materials and rubbish at all times.
   2. At the conclusion of each work shift, remove empty boxes, crates, surplus and waste materials, and other debris, and sweep clean all work areas affected by the Contractor’s work.
   3. In occupied areas affected by the Contractor’s work, the Contractor shall remove all evidence of the Contractor’s work in those areas at the end of each work shift, including tools, equipment and scaffolding, leaving the area clean, unobstructed and fully useable by the occupants.

B. At project completion, and prior to Final Acceptance:
   1. Remove all tools, equipment and scaffolding.
   2. Remove temporary labels and adhesives.
   3. Thoroughly vacuum the interior of enclosures to remove debris.
   4. Clear surplus product, materials and debris from the job site.
   5. Turn over equipment to the Owner in unblemished condition.
   6. Thoroughly clean equipment and facilities inside and out, and remove all residue -- all areas affected by the Work shall cleaned.
   7. Turn over the Work to the Owner in a fully operational state.

C. All final cleanup work shall be performed by professional cleaners qualified and skilled in the trade. The Contractor shall not make use of unqualified personnel for cleanup work.
D. The Project shall not be considered complete until all area affected by the Work are left in a clean, neat, orderly, and fully operable condition.

3.10 SUBSTANTIAL COMPLETION

A. Due to the technical nature of the Work, as well as the requirement that certain Owner provided equipment, systems, and training may necessitate use of the Work by the Owner prior to Substantial Completion, the Owner reserves the right to use the Work prior to Substantial Completion (when ready for use) without obligation to the Contractor and without implying Acceptance of the Work.

B. Pre-Substantial Completion Submittal: Three weeks prior to Substantial Completion, the Contractor shall prepare and submit the following:
   1. Known Exceptions/Deviations List:
      a. The Contractor shall compile a thorough list of known exceptions/deviations (in materials, construction, and/or workmanship) from that specified in the Contract Documents, and for which there was not associated documentation in the form of Change Orders (CO), Construction Change Directives (CCD), Architects Supplemental Instructions (ASI), or responses to a Request for Information (RFI).
      b. The Contractor shall submit the list to the Engineer for review. The Engineer shall review each item and mark as either Accepted or Not Approved.
         1) Items marked “Not Approved” shall be corrected by the Contractor to conform with the intent of the Contract Documents at no additional cost to the Owner.
         2) The Contractor shall perform corrective action for “Not Approved” items prior to notifying the Engineer that the work is Substantially Complete.
   2. Other information as called for in the individual Specification Sections.
   3. Owner Specific: Submit other information as required by Owner Specific Governing Requirements.

C. Notice of Substantial Completion: When the Work nears Substantial Completion, the Contractor shall notify the Engineer in writing the date that the work will be Substantially Complete and ready for review by the Engineer.

3.11 PROJECT CLOSE-OUT

A. Punchlist:
   1. Once notice of Substantial Completion is received, the Engineer shall visit the site to review the Work, and shall prepare a punchlist of items determined to be incomplete, deficient or otherwise not in compliance with the intent of the Contract Documents.
      a. During the review of the Work, if the Engineer finds that the Known Exceptions/Deviations List provided by the Contractor was insufficiently thorough, that the Work is not Substantially Complete, or that deficiencies in the work are excessive, the Engineer will cease review and inform the Contractor that the work is not Substantially Complete. The Contractor shall be responsible for fees incurred by the Engineer for this partial review.
   2. The Contractor shall perform corrective action for each item noted in the punchlist. When complete, the Contractor shall submit the original punchlist with each item initialed attesting to the fact that the item was corrected.
      a. If necessary, the Engineer will perform a subsequent review after receipt of the Contractor initialed punchlist.
   3. Should additional reviews beyond the original punchlist review be required of the Engineer due to the Contractor’s failure to correct all incomplete, deficient, or non-compliant work, the Contractor shall be responsible for fees incurred by the Engineer for the additional reviews.
B. Provide O&M Manuals per the requirements of *Part 1 – General: Operating & Maintenance (O&M) Manuals* herein.

END OF SECTION
PART 1 - GENERAL

1.1 SUMMARY
A. This Section defines Contractor qualifications and requirements for bidding the various systems in this Division.

1.2 QUALIFICATIONS FOR BIDDING
A. Contractors shall be qualified to bid per the requirements of Part 1 – General: Contractor Qualifications herein. Qualification criteria shall be satisfied prior to the date of Bid.

B. Pre-qualified Contractors:
   1. The following Contractors have met the qualification requirements and are pre-approved (by system type) to bid the Work:
      a. Electrical
         1) EmpowerCom
         2) Guarantee Electric
         3) K&M Communication
         4) Sturgeon Electric
         5) TeleSupport Services

C. Other Contractors must be qualified to bid per the requirements of Part 1 – General: Contractor Qualifications herein.
   1. Contractors shall submit their Statement of Qualifications (see Part 1 – General, Statement of Qualifications herein) with their bid. Bids which are submitted without a Statement of Qualifications or bids submitted with a Statement of Qualifications that is incomplete or does not clearly demonstrate that the qualification requirements have been met shall be rejected.

1.3 CONTRACTOR QUALIFICATIONS
A. General
   1. Experience:
      a. Governing Requirements: The Contractor shall have demonstrated, in-depth and working knowledge of the applicable portions of the Governing Requirements as noted in Division 27 Specification Section Basic Communications Requirements and as they pertain to the systems to be installed by the Contractor. The Contractor shall provide a signed statement stating same.
      b. Design and Installation Practices: The Contractor shall have demonstrated, in-depth and working knowledge of the generally accepted design and installation practices for the systems to be installed by the Contractor. The Contractor shall provide a signed statement stating same.
      c. Contractor References:
         1) Project: The Contractor shall provide references for no less than five similar projects (in terms of size and construction cost) performed by the Contractor within the past three years.
a) The reference list shall detail, for each project:
   i. Project name and location
   ii. Construction cost
   iii. A brief description of the project and the components involved
   iv. Contact names, phone numbers, and addresses
   v. Date completed
b) A minimum of two of the references shall be in the vicinity of the Project and shall be available for the Owner and Engineer to visit and inspect the installation.
   The Contractor shall highlight or otherwise make note of these particular references.

2) Service Department: The Contractor shall provide a minimum of two references for the Contractor’s Service Department. A minimum of one of the references shall be in the vicinity of the Project.

2. Manufacturer(s) Certification:
   a. The Contractor shall be trained and certified by the Manufacturer(s) to install, test, and maintain the major components of the system, shall be certified to perform service and equipment modifications without voiding the Manufacturer(s) warranty, and shall be certified by the Manufacturer(s) to provide these services in the location in which the Work is to be performed. The Contractor shall provide evidence of same for each major component Manufacturer – statements on letterheads from distributor, importer or local sales representatives are not be acceptable.

3. Offices:
   a. Locations: Provide locations of all regularly/fully staffed and operational offices and the number of administrative staff and technical personnel in each. Indicate which office(s) have a Service Department, and of those offices, indicate the number and type of personnel staffing the Service Department.
   b. Service Department: The Contractor shall maintain a permanently staffed and equipped Service Department, regularly providing services for the systems to be installed by the Contractor. The Contractor shall provide a signed statement stating same.
   c. The Contractor shall be licensed, bonded, and insured in the State in which the Work is to be performed. The Contractor shall provide evidence of same.
   d. If required by the locality, the Contractor shall be licensed by the locality. The Contractor shall provide evidence of same.

4. Personnel:
   a. Project Manager: The Contractor’s Project Manager assigned to this project shall have a minimum of three years continuous contracting project management experience on projects of similar size and complexity. The Project Manager shall have the authority to act for the Contractor, shall serve as the technical liaison between the Contractor and the Engineer, shall represent the Contractor at all meetings, shall be responsible for supervision of all work required to execute the Contract, shall review and approve all submittals prior to submission, and shall be present at the job site during final inspection. The Contractor shall provide a resume for the Project Manager which shall include:
      1) A summary of the Project Manager’s experience, including education, with emphasis on key skills relating to project management and the technical aspects of the systems for which the Project Manager will have responsibility.
      2) A listing of continuous projects (with dates) over the past three years on which the Project Manager performed project management duties. Project information shall include:
         a) Project name and location
         b) Construction cost
         c) A brief description of the project and the components involved
         d) Contact names, phone numbers, and addresses
         e) Date completed
b. Foreman: The Contractor’s Foreman assigned to this project shall have a minimum of three years continuous supervision experience on projects of similar size and complexity. The Contractor shall provide a resume for the Foreman which shall include:
   1) A summary of the Foreman’s experience, including education, with emphasis on key skills relating to installation supervision and the technical aspects of the systems for which the Project Foreman will have responsibility.
   2) A listing of continuous projects (with dates) over the past three years on which the Foreman performed supervisory duties. Project information shall include:
      a) Project name and location
      b) Construction cost
      c) A brief description of the project and the components involved
      d) Contact names, phone numbers, and addresses
      e) Date completed

c. Employee Certification: Contractor personnel directly involved with the supervision, installation, testing, and certification of the system shall be trained and certified by the major component Manufacturer(s). The Contractor shall provide evidence of same.

B. Systems Specific Qualifications: Additional Contractor Qualifications are required for each system as follows:
   1. Communications Cabling
      a. The Contractor shall be completely familiar with and have extensive working knowledge of the TIA/EIA standards for telecommunications systems, the design and installation practices as defined in the BICSI Telecommunications Distribution Methods Manual, and the installation practices as defined in the BICSI Telecommunications Cabling Installation Manual. The Contractor shall provide a signed statement stating same.
      b. RCDD: The Contractor shall assign an RCDD (Registered Communications Distribution Designer) to the project. The RCDD shall be a permanent member of the Contractor’s staff (i.e. an RCDD consultant/sub-contractor to the Contractor is not acceptable) and shall be in current good standing with BICSI. The Contractor shall provide the name of and evidence of certification for the Contractor’s RCDD to be assigned to the project.
      c. Manufacturer Certification: The Contractor shall be trained and certified by the specified communications cabling system Manufacturer to install, test, and maintain the communications cabling system, shall be certified by the Manufacturer to provide the Manufacturer’s most comprehensive performance and product warranty per the requirements of Division 27 Specification Section Warranty and it’s related sub-sections, and shall be certified by the Manufacturer to provide this warranty in the location in which the work is to be performed. The Contractor shall provide evidence of same.
         1) The Contractor shall be Manufacturer Certified as one or more of the following:
            a) Hubbell/Mohawk Mission Critical Certified Installer (CI)
      d. Employee Certification: Contractor personnel shall be trained and certified by the Manufacturer as follows. The Contractor shall provide evidence of same:
         1) Project Foreman and Supervisors: All (100 percent) shall be trained/certified by the Manufacturer for design, installation and testing.
         2) Technicians (responsible for testing, termination, connectorization, and determination of pathway/routing, and technical labor): All (100 percent) shall be trained/certified by the Manufacturer for installation and testing.
         3) Installers (responsible for cable installation, non-technical labor, etc.): Not required (subject to the requirements of the Manufacturer’s warranty and that of the next paragraph). However, these technicians must be directly supervised by a certified Installation Technician in an on site ratio of not less than one Manufacturer certified Installation Technician per two non-certified installers.
4) Other personnel: Personnel not directly responsible for installation supervision, installation, testing or certifying the communications cabling system (i.e. project managers, cleanup crew, etc.) are not required to be manufacturer trained and certified.

2. Audiovisual
   a. Programmer Certification: The Contractor shall have Manufacturer certified programmers for all equipment requiring programming. The Contractor shall provide evidence of same.
   b. In-House Capabilities: The Contractor shall have in-house capabilities and facilities for rack assembly, shop fabrication, and programming. The Contractor shall provide a signed statement stating same.
   c. Product Dealer Information: Provide a list of manufacturers/products for which the Contractor is a Dealer. Provide the duration of the relationship and the extent of manufacturer/product training.

3. Security
   a. Programmer Certification: The Contractor shall have Manufacturer certified programmers for all equipment requiring programming. The Contractor shall provide evidence of same.
   b. In-House Capabilities: The Contractor shall have in-house capabilities and facilities for rack assembly, shop fabrication, and programming. The Contractor shall provide a signed statement stating same.
   c. Product Dealer Information: Provide a list of manufacturers/products for which the Contractor is a Dealer. Provide the duration of the relationship and the extent of manufacturer/product training.

4. Low Voltage (CATV Distribution Network)
   a. Programmer Certification: The Contractor shall have Manufacturer certified programmers for all equipment requiring programming. The Contractor shall provide evidence of same.
   b. In-House Capabilities: The Contractor shall have in-house capabilities and facilities for rack assembly, shop fabrication, and programming. The Contractor shall provide a signed statement stating same.
   c. Product Dealer Information: Provide a list of manufacturers/products for which the Contractor is a Dealer. Provide the duration of the relationship and the extent of manufacturer/product training.

5. Electrical
   a. Refer to Division 26 for Electrical Contractor requirements.

1.4 STATEMENT OF QUALIFICATIONS (SOQ)

A. The Contractor shall prepare a Statement of Qualifications which shall include all documentation verifying compliance with the requirements of and as called for in Part 1 – General: Contractor Qualifications herein. The Statement of Qualifications shall include, at a minimum:

   1. General:
      a. Governing Requirements Statement
      b. Design and Installation Practices Statement
      c. Contractor Project References
      d. Contractor Service Department References
      e. Evidence of Manufacturer(s) Certification
      f. Office locations and information
      g. Service Department Statement
      h. Evidence of licensing, bonding, and insurance
      i. Project Manager Resume
      j. Foreman Resume
2. Systems Specific Statement of Qualifications: There are additional SOQ requirements for each system. The Contractor shall include the following system specific documentation within the Statement of Qualifications specified above:

a. Communications Cabling
   1) TIA/EIA Standards and BICSI Practices Statement
   2) Evidence of certification for the Contractor’s RCDD assigned to the project
   3) Evidence of Manufacturer(s) Certification and Warranty
   4) A list of personnel to be assigned to the project, the type of work they will be performing, and evidence of Manufacturer(s) Training/Certification for those personnel for which training/certification is required.

b. Audiovisual
   1) Evidence of Programmer Certification
   2) In-house Capability Statement
   3) Product Dealer Information

c. Security
   1) Evidence of Programmer Certification
   2) In-house Capability Statement
   3) Product Dealer Information

d. Low Voltage (CATV Distribution Network)
   1) Evidence of Programmer Certification
   2) In-house Capability Statement
   3) Product Dealer Information

e. Electrical
   1) No additional information is required.

B. A Statement of Qualifications that is incomplete or does not clearly demonstrate that the qualification requirements have been met shall be rejected

1.5 SUBMITTALS
A. Provide the following per the criteria set forth in Submittals in Division 27 Specification Section
   Basic Communications Requirements:
   1. Other Information:
      a. Provide a Statement of Qualifications for each Contractor and for each system to be provided by the Contractor.

PART 2 - MATERIALS

2.1 THIS SECTION NOT USED

PART 3 - EXECUTION

3.1 THIS SECTION NOT USED

END OF SECTION
SECTION 27 00 30
BIDDING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section provides requirements for bidding, including a format and definitions for the presentation of pricing for the base bid, and where applicable, alternate bid(s) and unit pricing. The contents of this Section are intended to establish pricing breakdowns which are useful to the Owner and the Engineer for evaluating bid responses.

B. Information as called for in this Section shall be provided per the requirements of the General Provisions of the Contract, Bidding Documents, Contract Forms, General Conditions, and the Construction Documents.

1.2 BASIS OF BID

A. The Contractor shall determine all existing conditions affecting the work, the type of construction to be used, and the nature and extent of work provided by other trades. Failure to do so shall be construed as willingness to provide complete and fully operational system(s) within the amount bid by the Contractor.

B. The Contractor shall notify the Engineer a minimum of ten (10) days prior to the bid date in the event of any of the following circumstances:
   1. Required items or details have been omitted from the Construction Documents
   2. Discrepancies or conflicts between the requirements of the Drawings and the Specifications, between the Governing Requirements and the Construction Documents, and between the various Governing Requirements.
   3. Discrepancies or conflicts between the requirements of this Division (27) and those of Division 0 or Division 1.

C. Where omissions, discrepancies, or conflicts are not brought to the attention of the Engineer, it shall be assumed that the most stringent requirement(s) constitute the basis for the Contractor’s bid, and as such shall be construed as willingness by the Contractor to provide complete and fully operational system(s) within the amount bid.

D. Fees for necessary or required licenses, permits, and inspections shall be included in the bid amount.

E. Bids shall be based on products, materials and methods of construction as specified. Bids based upon substitution of product and materials, as well as deviations from the methods of construction specified, shall be at the sole risk of the Contractor and as such are subject to rejection without consideration at the time of submittal review – should the Contractor be awarded the contract.

F. If the bidder proposes to sub-contract portions of the work, sub-contractors shall be identified and their Statement of Qualifications (per Division 27 Specification Section Contractor Qualifications) submitted as part of the Bidder’s bid submission.
   1. The Contractor is responsible for any and all work performed by a sub-contractor, and shall provide direct and continuous supervision of the sub-contracted work. Furthermore, this clause applies to any work provided by the Manufacturer(s) for equipment installation at the Contractor’s request.
G. By submitting a Bid, the Contractor agrees:
1. To honor the Contractor’s Bid for 90 days subsequent to the date that bids are opened.
2. To enter into and execute a Contract, if awarded, and to furnish all bonds and insurance
   required by the Contract Documents.
3. To accomplish the Work in accordance with the Contract Documents.
4. To complete the Work within the schedule stipulated by the Contract.

1.3 BID FORMAT

A. The Bid shall contain the following mandatory documentation. Bids submitted without this
documentation (in whole or in part) may be rejected without review. The documentation shall
be provided in addition to any forms/documents required by the General Provisions of the
Contract and/or the contracting authority.
1. Statement of Qualifications: Provide per Division 27 Specification Section Contractor
   Qualifications and/or its sub-sections.
2. Bid Form: A bid form summarizing the Contractor’s bid as required by the General
   Provisions of the Contract and/or the Contracting Authority.
3. Bid Supplement: Complete the Bid Supplement attached to the end of this Section.
   a. The Bid Supplement shall be completed in addition to any forms/documentation required
      by the General Provisions of the Contract and/or the contracting authority.
4. Additional Information:
   a. Subcontractor Identification: Identify sub-contractors and their responsibilities.
   b. Bill of Materials (BOM): The BOM shall include each item individually priced, and
      shall reflect any and all required modifications, accessories, and labor for the item. Each
      item listed shall be complete with the following information:
      1) Description
      2) Part number (if applicable)
      3) Quantity included in bid
      4) Material cost (including all required modifications, accessories and incidental
         materials)
      5) Labor cost to install (if applicable)
      6) Total installed price

1.4 ALTERNATE PRICING

A. An Alternate is an amount proposed by the Contractor and stated on the Bid Form for certain
work defined in the Construction Documents that may be added to or deducted from the Base
Bid amount.
1. The cost or credit for an alternate is the net addition to or deduction from the Base Bid to
   incorporate the alternate into the work.
2. Alternate pricing shall include all costs of related coordination, modification, or adjustment
   of the work to accommodate and completely integrate the Alternate into the project, and shall
   include all necessary materials, labor, delivery, insurance, applicable taxes, overhead,
   markups and profit.

B. Provide alternate pricing for the addition/deduction of the work specified below.

1. All Systems:
   1) ADD Alternate #1: Floors 2 and 3, Middle Research Wing: ADD Alternate #1 shall
      complete the lab construction (fit-up) of the second and third floors of the middle
      research wing, shelled in the base bid. This would leave the third wing and the two
      educational classrooms as shelled.
2) ADD Alternate #2: Floors 1, 2 and 3, North Research Wing: ADD Alternate #2 shall complete the lab construction (fit-up) of the first, second and third floors of the north research wing, shelled in the base bid. This would leave only the two educational classrooms as shelled.

3) ADD Alternate #3: Shelled Classrooms and First Floor Teaching Labs: ADD Alternate #3 shall complete the lab construction (fit-up) of the two shelled classrooms at the front of the building and the teaching labs on the First Floor.

4) ADD Alternate #4: Core and Shell, Fourth North Research Wing: ADD Alternate #4 constructs the core and shell of the fourth (north) research wing. This Alternate would leave all four floors as shelled space for future research labs. The shelled space would be constructed with penthouse mechanical systems and building shafts, minimal lighting, fire protection and exiting under the ADD Alternate.

5) ADD Alternate #5: Research Laboratories, Fourth North Wing: ADD Alternate #5 would complete the research laboratories (fit-up) in the fourth (north) wing. This would complete the full build-out of the project as defined in the Schematic Design documents.

2. Communications Cabling:
   a. ADD Alternate #6: Copper Splicing

3. Electrical:
   1) ADD Alternate #7: Extend Conduit from new north vault to Vault 7163: Provide new (2) 4-inch conduit Type 3 ductbank from intercept point to existing Manhole/Vault 7163 (should existing 2-duct ductbank be crushed or otherwise unusable)
   2) ADD Alternate #8: Extend Conduit from new south vault to Vault 6747: Provide new (2) 4-inch conduit Type 3 ductbank from intercept point to existing Manhole/Vault 6747 (should existing 2-duct ductbank be crushed or otherwise unusable).
   3) DEDUCT Alternate #9: Delete ductbank section. – Delete (2) 4-inch conduit Type 1 ductbank between new Communications Vaults.

1.5 UNIT PRICING

A. Unit pricing is a price per unit of measurement for materials, equipment and/or labor added to or deducted from the Contract Sum by appropriate modification. Unit pricing is to be provided for common items which may be added or deleted during the course of construction.

1. It is the intent that components added by unit price during construction shall result in complete and operable components ready for the Owner’s use. It is further the intent that components deducted by unit pricing shall not adversely impact the remaining or adjacent work.

2. Unit prices shall include all costs of related coordination, modification, or adjustment of the Work to accommodate and completely integrate the component into the project, and shall include, but shall not be limited to, all necessary materials, labor, programming, incidentals, delivery, insurance, applicable taxes, overhead, markups and profit.

3. Unit pricing shall remain in effect until Final Acceptance.

B. Provide unit prices for the addition/deduction of the items specified below. Unit pricing is broken out by the system(s) to which they pertain.

1. Communications Cabling:
   a. Horizontal Outlet: Cable, faceplate, connectors (station and patch panel), terminations, incidental materials, testing, labeling, etc. for any location (regardless of distance from the Telecommunications Room). Provide pricing by outlet type and port quantities as follows:
      1) Prior to walls covered and ceiling installed:
         a) 1-port
         b) 2-port
         c) 3-port
         d) 4-port
2) After walls covered and ceiling installed:
   a) 1-port
   b) 2-port
   c) 3-port
   d) 4-port
b. Wireless Access Enclosure: One enclosure, including and all incidental materials for hanging and support, installed.

2. Audiovisual:
   a. Projector
   b. Video Display
   c. Overhead Loudspeaker
   d. Document Camera

3. Security:
   a. Service Contract
   b. Wall Camera – Type P
   c. Wall Camera – Type F1
   d. Ceiling Camera – Type A
   e. Card Reader
   f. Access Control Door – Type C1A
   g. Access Control Door – Type C2A

4. Electrical:
   a. Outlet Box Raceway: One recessed single gang 4 inch by 4 inch deep outlet box at the horizontal outlet location with conduit raceway from the outlet box location to:
      1) Cable tray
      2) Telecommunications Room
   b. Cable Tray: One foot of cable tray, installed complete with all hanging/mounting hardware, bends, drops, etc. for a complete and functional cable tray system:
      1) 12 inch wide tray
   c. Door Control Raceway: One raceway system for an access controlled door, including conduit raceway and device box(es) necessary for all control devices:
      1) Single Door
      2) Double Door
d. Cable Pathway Firestopping Device: One device, installed.

PART 2 - MATERIALS

2.1 THIS SECTION NOT USED

PART 3 - EXECUTION

3.1 THIS SECTION NOT USED
**BID SUPPLEMENT**

**DIVISION 27 - COMMUNICATIONS**

**BASE BID**

Project Information

**PROJ NO:** HDR 08-001  **PROJECT NAME:** UCB - Systems Biotechnology Building

Contractor Information

**COMPANY NAME**  **CONTACT PERSON / TITLE**  **PHONE**  **FAX**

**ADDRESS**  **CITY**  **STATE**  **EMAIL**

Addenda Received

<table>
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Base Bid Breakdown (before applicable taxes)

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<th>LABOR</th>
<th>MATERIALS</th>
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<tr>
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<td>Security - Access Control</td>
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<td>4</td>
<td>Electrical Infrastructure</td>
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<td>5</td>
<td>Low Voltage - CATV Distribution</td>
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Required Attachments

- [ ] Statement of Qualifications
- [ ] Subcontractor(s) Identification
- [ ] Bill of Materials

Required Attachments

<table>
<thead>
<tr>
<th>ATT NO</th>
<th>ATT DOCUMENT</th>
</tr>
</thead>
</table>

| UNPRICED |

Signature

The undersigned, having carefully examined the Contract Documents, and being familiar with all conditions affecting the Work including but not limited to the availability of materials and labor, and furthermore being fully authorized to act on behalf of the bidder, agrees to furnish all labor and materials required for the construction of the Work in accordance with the accompanying Contract Documents, and further agrees that the information provided on all pages of this Bid Supplement is correct and will be honored by the Contractor, and as such is incorporated into and made part of the Contractor’s Bid.

**SIGNATURE**  **PRINTED NAME**  **PRINTED TITLE**  **DATE**
### BID SUPPLEMENT

**DIVISION 27 - COMMUNICATIONS**

**ALTERNATES**

The Base Bid may be increased or decreased by the following Alternates. If bidding more than one system, the Add/Deduct amounts for a given Alternate line item shall represent the sum total for all systems that are applicable to that line item. The Alternates listed may not be applicable to all systems. Alternates applicable to a given system will be indicated by a bullet (●) in the 'Applies to this System' column. Provide all Alternate pricing required for each system being bid. Refer to the 'Bidding' section of the Specifications for a more detailed description of these Alternates.

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<tr>
<th>ALTERNATES</th>
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<th>DEDUCT</th>
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<td>ADD ALTERNATE 1: Floors 2 and 3, Middle Research Wing</td>
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<tr>
<td>ADD ALTERNATE 2: Floors 1, 2 and 3, North Research Wing</td>
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<td>-$</td>
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<tr>
<td>ADD ALTERNATE 3: Shelled Classrooms and First Floor Teaching Labs</td>
<td>● ● ● ●</td>
<td>$</td>
<td>-$</td>
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<tr>
<td>ADD ALTERNATE 4: Core and Shell, Fourth North Research Wing</td>
<td>● ● ● ●</td>
<td>$</td>
<td>-$</td>
</tr>
<tr>
<td>ADD ALTERNATE 5: Research Laboratories, Fourth North Wing</td>
<td>● ● ● ●</td>
<td>$</td>
<td>-$</td>
</tr>
<tr>
<td>ADD ALTERNATE 6: Copper Splicing</td>
<td>●</td>
<td>$</td>
<td>-$</td>
</tr>
<tr>
<td>ADD ALTERNATE 7: Extend conduit to Vault 7163</td>
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<td>$</td>
<td>-$</td>
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<tr>
<td>ADD ALTERNATE 8: Extend conduit to Vault 6747</td>
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<td>$</td>
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<tr>
<td>DEDUCT ALTERNATE 9: Delete section of duct bank</td>
<td>●</td>
<td>$</td>
<td>-$</td>
</tr>
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### UNIT PRICING

The Base Bid may be increased or decreased by the following Unit Prices. If bidding more than one system, the Add/Deduct amounts for a given Unit Price line item shall represent the sum total for all systems that are applicable to that line item. The Unit Prices listed may not be applicable to all systems. Unit Prices applicable to a given system will be indicated by a bullet (●) in the 'Applies to this System' column. Provide all Unit Prices required for each system being bid. Refer to the 'Bidding' section of the Specifications for a more detailed description of these Unit Prices.

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<th>ALTERNATES</th>
<th>APPLIES TO THIS SYSTEM</th>
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<tr>
<td>Horizontal Outlet (prior to walls covered), 1-port, each</td>
<td>●</td>
<td>$</td>
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<td>Horizontal Outlet (prior to walls covered), 2-port, each</td>
<td>●</td>
<td>$</td>
<td>-$</td>
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<tr>
<td>Horizontal Outlet (prior to walls covered), 3-port, each</td>
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<tr>
<td>Horizontal Outlet (prior to walls covered), 4-port, each</td>
<td>●</td>
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<tr>
<td>Horizontal Outlet (after walls covered), 1-port, each</td>
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<td>Horizontal Outlet (after walls covered), 3-port, each</td>
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<td>Horizontal Outlet (after walls covered), 4-port, each</td>
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<td>Wireless Access Endosure, each</td>
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<td>Cable Tray, 12-inch wide (foot)</td>
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<td>Door Control Raceway, Single Door, each</td>
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<td>Cable Pathway Firestopping Device, each</td>
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<td>Control Panel, each</td>
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<td>Access Control Door – Type C2A</td>
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SECTION 27 00 40
WARRANTY

PART 1 - GENERAL

1.1 SUMMARY
A. This Section defines general warranty requirements for the Communications System(s).

1.2 GENERAL
A. Warranty
1. The Contractor shall warrant the Work against all defects in materials, equipment and workmanship in compliance with the applicable requirements of Division 1.
2. Manufacturer Warranties: The Contractor’s Warranty shall include all Manufacturer Warranties. The Contractor shall represent and act on the Owner’s behalf in any and all Manufacturer warranty/replacement proceedings.
3. Manufacturer Support Contract(s): The Contractor shall provide any manufacturer backed maintenance, warranty and/or technical support contract necessary for the Contractor to configure, operate, service, repair and/or replace any component of the Communication System(s). The contract shall be valid for the duration of the warranty period. The Contractor shall purchase the contract in the Owner’s name and provide documentation and renewal information to the Owner at acceptance testing.
4. The Contractor shall comply with the Submittal portions of Division 27 Specification Section Basic Communications Requirements.
5. All labor, materials, equipment, and other costs and services necessary for the fulfillment of the Warranty shall be provided at no charge to the Owner.

B. Warranty Period
1. Unless otherwise noted, the minimum Warranty Period shall be 1 year or as otherwise called for in the General Provisions of the Contract.
2. The Warranty Period shall commence upon Final Acceptance.
3. Manufacturer Warranties:
   a. The Contractor shall honor Manufacturer Warranties for the full term established by the Manufacturer when said term is greater than the Warranty Period.
   b. In cases where Manufacturer Warranties are less than the Warranty Period, the Contractor is liable for and shall warrant the Manufacturer’s equipment for the entire term of the Warranty Period.
   c. Where the Contractor has modified equipment, the Manufacturer’s warranty may be voided. In such cases, the Contractor shall warrant the Manufacturer’s equipment for a term equivalent to that of the original Manufacturer Warranty term, or for the entire Warranty Period, whichever is greater.

C. Warranty Certificate
1. The Contractor shall provide a written Warranty Certificate on the Contractor’s letterhead, signed by the Contractor, with terms and conditions of the Warranty complying with the requirements detailed herein.
2. The Warranty Certificate shall include copies of all Manufacturer Warranties. Manufacturer Warranties shall be activated by the Contractor in the Owner’s name.
3. The Warranty Certificate shall be submitted as part of the O&M Manual submission.

D. Warranty Fulfillment
1. The Contractor shall provide a Warranty service visit within 24 hours of notification.
2. Defects shall be remedied within 72 hours of notification.
1.3 SYSTEM SPECIFIC

A. The Contractor shall include the following additional system specific items as part of the Warranty above:

1. Communications Cabling
   a. Communications Cabling System Manufacturer Warranty: The Contractor shall provide a communications cabling system extended product, performance/application, and labor Manufacturer Warranty that shall warrant all passive components used in the communications cabling system. Additionally, this Warranty shall cover all components not manufactured by the Manufacturer, but approved by the Manufacturer for use in the communications cabling system (i.e. “Manufacturer Approved Alternative Products”).
      1) The Manufacturer Warranty shall warrant:
         a) That the products will be free from manufacturing defects in materials and workmanship.
         b) That all cabling products of the installed system shall exceed the specification of TIA/EIA 568 performance standards. For copper based cabling products, the TIA/EIA 568 Category rating of the specified system shall be exceeded.
         c) That the installation shall exceed TIA/EIA 568 installation standards.
         d) That the system shall be application independent and shall support both current and future applications that use the TIA/EIA 568 component and link/channel specifications for cabling.
         e) That all labor and materials and other costs attributable to the fulfillment of the Manufacturer Warranty shall be provided at no additional cost to the Owner.
      2) The Manufacturer Warranty shall be:
         a) Hubbell Mission Critical 25-Year Warranty and System Performance Guarantee
      3) Manufacturer Warranty Period:
         a) The Manufacturer Warranty Period shall commence upon Final Acceptance or a Warranty Certificate being issued by the Manufacturer, whichever is later.
      4) Manufacturer Warranty Certificate:
         a) The Manufacturer Warranty Certificate shall be included with the Contractor Warranty.

2. Audiovisual
   a. Replacement: Defective components which cannot be serviced within five business days due to unavailability of parts or services shall be replaced with new, identical components. If new and identical components are not available, the Contractor may provide new and equal substitutes upon Owner approval. Replaced components shall become the property of the Owner, and shall be warranted by the Contractor for the remaining term of the Warranty Period, or the term of Manufacturer’s Warranty, whichever is longer.
   b. Preventative Maintenance: The Contractor’s Warranty shall include 4 preventative maintenance visits during the Warranty Period for the purposes of verifying equipment operation, cleaning and lubrication, minor modifications to programming, adjustment and alignment of equipment, and other minor services as necessary and as requested by the Owner.
      1) The Contractor shall submit a written summary of the maintenance work performed during each Preventative Maintenance visit within five business days of the visit.
   c. Exclusions: Lamps, fuses, and exterior finishes are specifically excluded from the Warranty, except where failure or damage is attributable to defective materials or workmanship.
3. Security
   a. Replacement: Defective components which cannot be serviced within five business days due to unavailability of parts or services shall be replaced with new, identical components. If new and identical components are not available, the Contractor may provide new and equal substitutes upon Owner approval. Replaced components shall become the property of the Owner, and shall be warranted by the Contractor for the remaining term of the Warranty Period, or the term of Manufacturer’s Warranty, whichever is longer.
   b. Preventative Maintenance: The Contractor’s Warranty shall include 2 preventative maintenance visits during the Warranty Period for the purposes of verifying equipment operation, cleaning and lubrication, minor modifications to programming, adjustment and alignment of equipment, and other services as necessary and as requested by the Owner.
      1) The Contractor shall submit a written summary of the maintenance work performed during each Preventative Maintenance visit within five business days of the visit.
   c. Exclusions: Fuses and exterior finishes are specifically excluded from the Warranty, except where failure or damage is attributable to defective materials or workmanship.

4. Low Voltage (CATV Distribution)
   a. Replacement: Defective components which cannot be serviced within five business days due to unavailability of parts or services shall be replaced with new, identical components. If new and identical components are not available, the Contractor may provide new and equal substitutes upon Owner approval. Replaced components shall become the property of the Owner, and shall be warranted by the Contractor for the remaining term of the Warranty Period, or the term of Manufacturer’s Warranty, whichever is longer.
   b. Preventative Maintenance: The Contractor’s Warranty shall include 4 preventative maintenance visits during the Warranty Period for the purposes of verifying equipment operation, cleaning and lubrication, minor modifications to programming, adjustment and alignment of equipment, and other services as necessary and as requested by the Owner.
      1) The Contractor shall submit a written summary of the maintenance work performed during each Preventative Maintenance visit within five business days of the visit.
   c. Exclusions: Fuses and exterior finishes are specifically excluded from the Warranty, except where failure or damage is attributable to defective materials or workmanship.

5. Electrical
   a. No additional warranty items required.

PART 2 - MATERIALS

2.1 THIS SECTION NOT USED

PART 3 - EXECUTION

3.1 THIS SECTION NOT USED

END OF SECTION
PART 1 - GENERAL

1.1 SUMMARY
A. This Section defines processes and procedures for quality assurance.

1.2 GENERAL QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)
A. Design Intent Meeting
1. The Contractor shall schedule and attend a meeting to review the design with the Engineer, Owner, and the General Contractor. The purpose of the meeting will be to ensure that the Contractor fully understands the design intent as detailed in the Contract Documents. The Contractor shall thoroughly review the Contract Documents prior to the meeting, and shall document questions, comments, and/or concerns to be discussed at the meeting. The meeting shall take place prior to Submittal preparation and submission. Attendees shall include:
   a. Communications Contractor(s)
      1) Communications Cabling
      2) Audiovisual
      3) Security
      4) Low Voltage
      5) Others as applicable
   b. Electrical Contractor
   c. General Contractor
   d. Engineer
   e. Owner
B. Pre-installation Meeting
1. Prior to beginning work in a given area (or areas), the Contractor shall schedule and attend a pre-installation meeting to review and coordinate work within that area with the other trades. The purpose of the meeting will be to review the communications pathway/raceway layout and identify and resolve any potential conflicts, to have each trade verify that the pathway/raceway sizing is sufficient for the cabling to be installed within, to ensure a consistent installation for all cabling, to minimize interference with adjacent materials and equipment, and to ensure that communications cabling and equipment is accessible to the Owner for future modifications and maintenance. The meeting shall take place a minimum of 30 days prior to communications pathway/raceway rough-in. Attendees shall include:
   a. Communications Contractor(s)
      1) Communications Cabling
      2) Audiovisual
      3) Security
      4) Low Voltage
      5) Others as applicable
   b. Electrical Contractor
   c. General Contractor
   d. HVAC/Mechanical Contractor
   e. Plumbing Contractor
   f. Engineer
   g. Owner
C. Inspections
   1. The Contractor shall schedule and coordinate all inspections of the work as required by the Governing Authorities. The Contractor shall be solely responsible for scheduling inspections by the Governing Authorities at times appropriate to the stage of construction and the work to be inspected. The Contractor shall provide all assistance as required by the inspector(s) during their inspection(s).
      a. Should the Governing Authorities require remedial action on the Contractor’s part due to the failure of the Contractor to schedule inspections at appropriate times, such work shall be at no additional cost to the Owner.
      b. The Contractor is solely responsible for scheduling inspections such that, should the work fail inspection, enough time remains in the project schedule to take remedial action and re-inspect the installation.

D. Observation of Work
   1. Work will be observed by the Engineer on a periodic basis. Work not found to be in compliance with the Construction Documents, or not in compliance with the intent of the Construction Documents, shall be brought into compliance at no additional cost to the Owner.
   2. The Contractor shall notify the Engineer at least one week in advance of the covering of concealed work so that the Engineer may schedule on-site observation of the work to be concealed. Work shall not be concealed until work has been tested (if applicable), observed by the Governing Authorities (if applicable), and at the Engineer’s discretion, observed by the Engineer. Should work be concealed prior to such testing and observation, it shall be uncovered, tested, observed, and restored by the Contractor to the finished condition at no additional cost to the Owner.

E. Coordination
   1. The Contractor shall thoroughly examine the Construction Documents, including Drawings and Specification Sections of other Divisions, for construction details and methods that are dependent upon or will affect the work of other trades. The Contractor is responsible for identifying coordination issues and dependencies, and for preparing Shop Drawings, work plans and schedules to accommodate or mitigate coordination issues and dependencies before they arise. Changes necessitated by the failure of the Contractor to coordinate with the work of other trades shall be at no additional cost to the Owner.
   2. The Contractor shall confer and cooperate with the other trades, throughout the entire construction process, in order to coordinate the work in the proper sequence. Typical coordination issues include but are not limited to:
      a. Electrical work, including but not limited to electrical receptacles, power panels, transformers, the telecommunications grounding system, and the installation of raceway, device boxes, conduits, cable tray, ladder racking and sleeves.
      b. Mechanical work, including but not limited to HVAC systems and ductwork, piping, and mechanical chases.
      c. Ceiling cavity spaces.
      d. Installation of acoustical ceiling tiles and similar finishes that may conceal the work.
      e. Build-in of oversized equipment during structure construction.
      f. Required separation distances.
      g. Access routes for equipment through the construction.
      h. Cutting/coring of floor, ceiling or wall structures.
   3. Verify that the physical dimensions of each item of equipment fit the available space, promptly notify the Engineer of any potential conflicts, and await the Engineer’s direction prior to purchase and rough-in of the equipment.
4. Coordinate locations of devices with field conditions, unless such locations are specifically dimensioned or otherwise noted in the Construction Documents. If so noted, verify location with other affected trades and against existing field conditions, promptly notify the Engineer of any potential conflicts, and await the Engineer’s direction prior to purchase and rough-in of the equipment.

5. Coordinate locations for chases, slots, sleeves, and openings in the building structure. For new concrete coordinate, locate and provide chases, slots, sleeves, and openings prior to the pouring of the concrete.

6. Outages shall be coordinated and scheduled in advance with the Owner at a time and duration acceptable to the Owner. Outages scheduled at times other than the normal working hours shall not entitle the Contractor to additional compensation beyond the original amount bid. Outages without advance notice and prior approval by the Owner are not acceptable.

7. Furniture and Casework: Prior to procurement and installation of materials and equipment within furniture and casework, the Contractor shall coordinate with other trades and verify all locations, pathway requirements, etc. Materials and equipment installed in furniture and casework without prior coordination are solely at the Contractor’s risk, and as such, are subject to possible rejection by the Engineer. Rejected materials and equipment shall be replaced and modified furnishings and casework shall be restored to its original condition at no additional cost to the Owner.

F. Verification and Validation

1. Measurements
   a. The Contractor shall physically verify and validate all measurements on site (i.e. actual measurements vs. those of the Drawings). Where discrepancies exist which could affect the Work or the Intent of the Construction Documents, the Contractor shall notify the Engineer and await the Engineer's direction, prior to procurement and installation of materials.

2. Raceway/Pathway Sizes
   a. Prior to procurement and installation of raceway/pathway, the Contractor is responsible for verifying and validating raceway/pathway (conduit, sleeves, cable tray, surface raceway, etc.) sizes with any and all trades which will make use of them. Where the calculated cable fill ratios exceed that recommended by the NEC and TIA/EIA 569, the Contractor shall notify the Engineer and await the Engineer's direction prior to procurement and installation of cable.

3. Equipment Locations
   a. Prior to the installation of equipment, the Contractor shall coordinate with other trades and subsequently verify all equipment locations that mount on walls or within ceilings. This work shall include but shall not be limited to:
      1) Structural elements such as lighting devices, HVAC equipment, fire protection devices, and cable tray.
      2) Structural support elements for ceiling mounted devices such as but not limited to speakers, cameras, projectors and projection screens.
      3) Backing Board for wall mounted devices such as but not limited to equipment panels, equipment panels, power supplies, head-end equipment, flat panel displays, speakers, and equipment room devices.
4. No additional compensation will be approved for additional work or materials required due to the Contractor’s failure to verify and validate the above.

G. Examination
1. The Contractor shall carefully examine the project site and the Construction Documents and shall be responsible for identifying all utility, state, and local requirements that will affect the Work.
2. The Contractor shall become familiar with the local conditions under which the work is to be performed and correlate those conditions with the requirements of the Construction Documents. No allowance will be made for claims of concealed conditions which the Contractor, exercising reasonable due diligence while examining the site, observed or should have observed.
3. The Contractor shall be responsible for determining if the Work will affect the operation or code compliance of existing systems. Where this is the case, the Contractor shall notify the Engineer and await the Engineer's direction prior to procurement and installation.

1.3 SYSTEMS SPECIFIC QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)
A. In addition to the quality assurance processes and procedures specified above, the Contractor shall provide the following for each system:
1. Communications Cabling
   a. Coordination:
      1) The Contractor shall review the Drawings and Specifications of other Divisions for locations of devices and equipment requiring communications connectivity not specified or shown on the Drawings of this Division. The Contractor shall coordinate the locations of these items with the other trades, and shall verify locations with the Engineer and Owner prior to rough-in.
      2) The Contractor shall facilitate and coordinate Service Providers installations with the Owner and with the Service Provider(s).
   b. Verification: The Contractor shall physically verify the following on site, prior to procurement and installation:
      1) Backbone Cable: Verify total run lengths for each backbone cable (inside and outside plant) from origination to destination using the pathways provided (ductbank, conduits, raceway, conduit, cable-tray, sleeves, open/accessile pathways, etc.), and including slack loops, vertical transitions, jogs, etc. Pre-cut cables of insufficient length are the sole responsibility of the Contractor.
      2) Station Cable: Verify total run lengths for each station cable from outlet location to communications room using the pathways provided (conduit, cable tray, sleeves, open pathways, etc.), and including slack loops, vertical transitions, jogs, etc. For run lengths which may exceed 270 feet, the Contractor shall obtain the Engineer’s direction prior to proceeding with the installation.
   c. Contractor RCDD Periodic Review:
      1) During the course of construction, the Contractor’s RCDD shall periodically perform an on-site review of the construction in progress and certify that the construction conforms to the requirements of the Governing Requirements, and in particular the TIA/EIA standards. The RCDD shall provide a written report to the Owner/Engineer on company letterhead that details the work reviewed and states that the work is in conformance with the Governing Requirements. The work in progress shall be reviewed and a report delivered to the Owner/Engineer on a bi-weekly basis.
d. Inspections:
   1) Inspections shall occur no later than one week after Substantial Completion. Furthermore, inspections shall be completed and certified no later than three weeks prior to the scheduled use of the system by the Owner.
   a) Manufacturer Inspection: The installation is required to pass all Manufacturer certification requirements.
      i. The completed installation shall be inspected by Manufacturer personnel, shall pass the Manufacturer inspection, and shall be certified by the Manufacturer to meet and be covered by the Manufacturer extended product warranty.
      ii. The Contractor is solely responsible for all costs associated with scheduling the Manufacturer inspection, the inspection itself, and for making any modifications to the installation as required by the Manufacturer at no additional cost to the Owner.
   b) RCDD Inspection: The installation is required to comply with the Governing Requirements.
      i. The Contractor’s RCDD shall inspect the completed installation and prepare a certificate on company letterhead certifying that the work complies with the Governing Requirements. The written certification shall be complete with the RCDD’s stamp/certification number and shall bear the RCDD’s signature across the face of the stamp. The certification shall be submitted with the O&M documentation.

2. Audiovisual
   a. Equipment locations: Prior to the installation of equipment, the Contractor shall coordinate with other trades and subsequently verify all equipment locations that mount on walls or within ceilings. This work shall include but shall not be limited to:
      1) Structural elements such as lighting devices, HVAC equipment, fire protection devices, and cable tray.
      2) Structural support elements for ceiling mounted devices such as projectors, projection screens, and speakers.
      3) Backing Board for wall mounted devices such as flat panel displays, speakers, and equipment room devices.

3. Security
   a. Equipment locations: Prior to installation of equipment, the Contractor shall coordinate with other trades and subsequently verify all equipment locations that mount on walls or within ceilings. This work shall include but shall not be limited to:
      1) Structural elements such as lighting devices, HVAC equipment, fire protection devices, and cable tray.
      2) Structural support elements for ceiling mounted devices.
      3) Backing Board for wall mounted devices such as equipment panels, power supplies, head-end equipment, etc..

4. Electrical
   a. Raceway/Pathway Size Validation: The Electrical Contractor is responsible for ensuring that the Raceway/Pathway sizes have been validated by all trades per the criteria set forth in Part 1 – General: General Quality Assurance/Quality Control (QA/QC), Verification and Validation, Raceway/Pathway Sizes above.
      1) Where discrepancies exist between the raceway/pathway sizes shown on the Drawings and the Contractor’s calculated sizes, the Contractor shall notify the Engineer and await the Engineer's direction prior to procurement and installation of the raceway/pathway.
PART 2 - MATERIALS

2.1 THIS SECTION NOT USED

PART 3 - EXECUTION

3.1 THIS SECTION NOT USED

END OF SECTION
PART 1 - GENERAL

1.1 SUMMARY
A. This Section defines training requirements for the various communications systems.

1.2 GENERAL REQUIREMENTS

A. Trainer/Instructor
1. The Instructor leading the training session(s) shall be a qualified and experienced trainer. Where the Contractor does not have a qualified and experienced trainer on staff, the Contractor shall arrange to have appropriate Manufacturer Representative(s) lead the training session(s).
2. The Contractor shall have the Project Manager and/or Foreman present during the training session(s) in order to assist the Instructor by providing “hands-on” operational knowledge of the installation and operations of the systems.
3. For complex/sophisticated equipment, the Contractor shall arrange to have the appropriate Manufacturer Representatives present during the training session(s).

B. Schedule and Location
1. The data and time of the training sessions(s) shall be coordinated with and approved by the Owner and Engineer. The Engineer may attend the training session(s) at the Engineer’s discretion.
2. The training sessions(s) shall occur within one month of Substantial Completion, unless otherwise approved by the Owner.
3. Training session(s) shall occur at the site, in order to provide the participants with “hands-on” experience.
4. Training may not necessarily occur in contiguous periods, depending upon the needs of the Owner (e.g. if a total of 8 hours of training is required, depending upon the needs of the Owner, it may be that two 2-hour periods and one 4-hour period spread across several weeks may be necessary).

C. Follow-up Training
1. Unless otherwise noted, provide one follow-up training session during the Warranty Period, scheduled at the request of the Owner. The follow-up training session shall occur after the Owner has had the opportunity to fully operate the system(s). The Contract shall not be considered complete until training has been completed.

PART 2 - MATERIALS

2.1 GENERAL
A. The final version of the O&M Manual(s) shall be used as the primary training aid.
B. Training materials and presentations shall be professional in appearance, organized, bound, and suitable for re-use by the Owner in the future. Provide training materials to each participant, plus an additional 10 copies to the Owner for future use. Training materials shall be provided on CD-ROM in addition to hardcopy.
PART 3 - EXECUTION

3.1 GENERAL
A. The Contractor shall provide training on the proper operation and routine maintenance of the various communications systems. Training shall include “hands-on” demonstrations.

B. Training shall not commence until the communications system(s) are complete, tested, and fully operational.

3.2 TRAINING
A. Provide training for each system as follows:
   1. Communications Cabling
      a. Training Session(s)
         1) Provide a total of 1.5 hour(s) of training, broken out approximately as follows:
            a) Overview of the Communications Cabling System and Warranty process: Provide 0.5 hour(s) of training
            b) Backbone Cabling: Provide 0.25 hour(s) of training
            c) Horizontal Cabling: Provide 0.25 hour(s) of training
            d) Communications Rooms and Spaces: Provide 0.5 hour(s) of training
         b. Follow-up Training: Not required.
   2. Audiovisual
      a. Training Session(s)
         1) Schedule training sessions to occur after the system is Substantially Complete but prior to Acceptance Testing.
         2) Provide a total of 8 hour(s) of training, broken out approximately as follows:
            a) Overview of Audiovisual System and Warranty process: 2 hour(s)
            b) Conference Room(s): 2 hour(s)
            c) Auditorium and Large Classroom(s): 4 hour(s)
         3) After Acceptance Testing, update the training materials to reflect any issues, configuration changes, etc. resulting from the Testing. Provide updated materials to Owner.
      b. Follow-up Training Session: Provide one 2 hour session.
   3. Security
      a. Training Session(s)
         1) Provide a total of 8 hour(s) of training, broken out approximately as follows:
            a) Security Cameras/Surveillance: 4 hour(s)
            b) Access Control System: 4 hour(s)
      b. Follow-up Training Session: Provide one 2 hour session for each system.

END OF SECTION
SECTION 27 04 05
COMMON WORK - SLEEVES, PENETRATIONS, AND FIRESTOPPING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes specific requirements for sleeves and penetrations common to the communications systems.

1.2 RELATED SECTIONS

A. The firestopping requirements of this Section are additional to, different from, or otherwise supplement the Section(s) in Division 7 which pertain(s) to thermal protection systems, such as firestopping and fire-resistive materials. The applicable requirements of these Section(s) shall serve as the basis for the requirements of this Section, and are incorporated by reference into this Section.

1.3 SUBMITTALS

A. Provide the following per the criteria set forth in Submittals in Division 27 Specification Section Basic Communications Requirements:
   1. Product Data
   2. Samples
      a. Provide samples of each type of Cable Pathway Firestopping Device.
      b. Provide samples of all firestop products/materials.

1.4 DEFINITIONS

A. EMT: Electrical Metallic Tubing

B. RMC: Rigid Metal Conduit

PART 2 - MATERIALS

2.1 GENERAL

A. Part Numbers: Refer to the equipment schedule at the end of this Section for specific part numbers. If no part number is provided, then any part meeting the requirements specified is acceptable.

2.2 SLEEVES

A. Provide sleeves for all locations where cable must pass-through building barriers such as walls, floors or foundations.

B. Sleeves consist of a penetration/opening in a barrier and a conduit section or Cable Pathway Firestopping Device passing through the penetration/opening.

C. Conduit sections used for sleeves shall be per the requirements of Division 27 Specification Section Electrical - Conduit and Boxes.
D. Conduit Sleeves shall be:
1. Cast-in-place: Provide RMC conduit sections unless otherwise shown on the Drawings
2. Cored: Provide EMT conduit sections unless otherwise shown on the Drawings
3. Non fire-rated barriers: Provide EMT conduit sections unless otherwise shown on the Drawings

E. Fire-rated Sleeves shall be:
1. For barriers other than floors: Cable Pathway Firestopping Device
   a. Devices shall be pre-manufactured enclosed fire rated pathway devices with a built-in fire sealing system sufficient to maintain the hourly rating of the barrier being penetrated. The self-contained sealing system shall automatically adjust to the installed cable loading and shall permit cables to be installed, removed, or maintained without the need to remove or reinstall firestop materials. The pathway shall be UL classified and FM/Systems approved, and shall be examined and tested to the requirements of ASTM E814 (UL1479). Use shall be per local codes. Sleeves shall be:
   1) Specified Technologies, Inc.: EZ-Path

2.3 FIRESTOPPING

A. General:
1. Provide firestopping material for all through and membrane penetrations of fire-rated barriers.
2. Firestopping material used to seal open penetrations through which cable passes shall be reusable/re-enterable.
3. Provide through-penetration firestop products that are compatible with one another, with the substrates forming openings, and with the penetrating items.
4. Provide firestop products that upon curing do not re-emulsify, dissolve, leach, breakdown or otherwise deteriorate over time from exposure to atmospheric moisture, sweating pipes, ponding water or other forms of moisture characteristic during and after construction.
5. Provide firestop sealants sufficiently flexible to accommodate motion such as pipe vibration, water hammer, thermal expansion and other normal building movement without damage to the seal.
6. Materials or sealants shall not contain flammable solvents or sodium silicate.
7. Products specified in this Section shall be UL Listed and Labeled.
8. Part Numbers: Refer to the equipment schedule at the end of this Section for specific part numbers. If no part number is provided, then any part meeting the requirements specified is acceptable.

B. Firestopping Materials
1. Material shall conform to both Flame (F) and Temperature (T) ratings as required by local building codes and as tested by nationally accepted test agencies per ASTM E814 or UL 1479 fire test in a configuration that is representative of the actual field conditions. Materials shall be complete with necessary accessory materials, as applicable, for complete UL listed and approved assemblies.
   a. Firestopping materials shall be:
      a) Hilti Re-enterable Putty
PART 3 - EXECUTION

3.1 GENERAL

A. Work shall comply with the Governing Requirements as defined in Division 27 Specification Section Basic Communications Requirements. Governing Requirements of particular relevance to this Section include, but are not limited to:
   1. NEC: National Electrical Code (NFPA Article 70)
   2. TIA/EIA 569: Commercial Building Standard for Telecommunication Pathways and Spaces

B. Installation shall be such that communications circuits, when installed in the pathways and penetrations specified herein, are able to fully comply with the following:
   1. TIA/EIA 568: Commercial Building Telecommunications Cabling Standard

3.2 SLEEVES

A. Provide sleeves for all locations where free hung cable must pass through building barriers such as walls, floors or foundations.

B. The Contractor shall provide all cutting, rough patching and finish patching as required for the installation of sleeves, and shall provide all penetrations, including core drilling, rotohammering, etc. as required.

C. Sleeves shall be sealed and firestopped (as appropriate to the fire rating of the barrier) between the conduit section (or cable pathway firestopping device) and the barrier penetration/opening.

D. Unless otherwise noted on the Drawings or specified herein, sleeves shall be sized according to the quantity and outside diameter of the cable(s) they are to support per NEC fill ratios and TIA/EIA 569 cable capacity standards, plus an additional 25 percent for future expansion.

E. Sleeve size shown on the Drawings reflects the size of the conduit or device passing through, not the size of the penetration/opening.

F. Conduit section sleeves:
   1. Conduits shall be installed per the requirements of Division 27 Specification Section Electrical - Conduit and Boxes.
   2. Unless otherwise noted on the Drawings, sleeve size through floors shall be 4 inch diameter.
   3. Conduit sections shall be installed complete with insulated throat bushings.

G. Cable Pathway Firestopping Device:
   1. Provide where cable trays must pass through fire rated barriers. Transition from cable tray to Cable Pathway Firestopping Devices at fire rated barriers.
      a. Provide devices in sufficient quantity such that the combined useable volume of the devices is greater than or equal to the volume of cable tray to be served.
   2. Provide where free hung cables must pass through fire rated barriers.
      a. Provide devices in sufficient quantity such that the combined useable volume of the devices is greater than one and one-half times the volume of the cable to be served.

3.3 PENETRATIONS

A. Properly size and locate penetrations required as construction progresses. For new concrete or masonry the Contractor shall coordinate, locate and provide required openings prior to the pouring of concrete or construction of masonry.
B. Penetration of concrete and structural elements shall be avoided where possible. Where not possible, obtain written approval from the Structural Engineer/Architect prior to penetration. Such penetrations shall be performed in a manner that will not reduce structural element load-carrying capacity or load-deflection ratio.

C. Penetrations shall be performed by workers qualified and skilled in the trades involved.

D. Penetrations (through and membrane) of fire rated barriers shall be firestopped and sealed. The fire rating of the barrier shall be strictly maintained.

E. Penetrations shall not be exposed on the exterior or in occupied spaces in a manner that would, in the Engineer’s opinion, reduce the aesthetic qualities of the structure or result in visual evidence of penetration and patching.

F. Penetrations shall be constructed using methods least likely to damage elements to be retained or adjoining construction.
   1. Provide temporary support for the work to be penetrated.
   2. In general, where cutting is required, use hand or small power tools designed for sawing or grinding, not for hammering or chopping. Cut holes and slots neatly to required size with minimum disturbance of adjacent surfaces. Temporarily cover openings when not in use.
   3. Cut or drill from the exposed or finished side into concealed surfaces to avoid marring of existing finished surfaces.
   4. Cut through concrete and masonry using a cutting device such as a Barborundum saw or diamond core drill.

G. Voids around penetrations shall be properly sealed, caulked or grouted as required.

H. Existing elements:
   1. The Contractor shall be responsible for identifying, locating, and protecting existing elements such as embedded conduits, pipe, ductwork, etc. when penetrating existing structures.
   2. Cap, valve, plug or seal remaining portions of cut pipes or conduit to prevent entrance of moisture or other foreign matter.
   3. The Contractor shall be responsible for repairing or replacing existing conduits, pipe, ductwork, etc. damaged by the Contractor during construction of penetrations. Repair or replacement shall be made at no additional cost to the Owner.

I. Penetrations (and subsequent patching) resulting from the Contractor’s failure to properly coordinate penetrations shall be at no additional cost to the Owner.

J. Penetrations shall be laid out and installed in advance to facilitate the installation of raceway through the penetrations.

3.4 FIRESTOPPING

A. Work shall be in accordance with the UL Fire Resistance Directory, fire test reports, fire resistance requirements, acceptable sample installations, manufacturer’s recommendations, local fire and building authorities, and codes.

B. Application of sealing material shall be accomplished in a manner acceptable to the local fire and building authorities.

C. The fire rating of all penetrated fire barriers shall be strictly maintained. All through penetrations as well as membrane penetrations of fire rated barriers shall be firestopped and sealed.

D. Installation shall be performed in strict accordance with manufacturer’s detailed installation procedures. Prepare surfaces per manufacturer’s instructions. After installation, clean all surfaces adjacent to sealed openings to be free of excess firestopping materials and soiling.
E. Personnel installing firestopping products shall be certified by the Manufacturer to install such products.

F. Install firestopping in open penetrations and in the annular space of penetrations for fire rated barriers.

G. Seal all openings or voids made by penetrations to ensure an air and water resistant seal.

H. Install firestopping such that the performance and effectiveness of other thermal and fire protective devices (such as fire/smoke dampers) in the area are fully maintained.

I. Protect materials from damage on surfaces subjected to traffic.

J. Apply a suitable bond-breaker to prevent three-sided adhesion in applications where this condition might occur such as the intersection of a gypsum wallboard/steel stud wall to floor or roof assembly where the joint is backed by a steel ceiling runner or track.

K. Where joint application is exposed to the elements, fire resistive joint sealant must be approved by the manufacturer for use in exterior applications and shall comply with ASTM C-920.

L. Do not install firestop products when ambient or substrate temperatures are outside limitations recommended by the manufacturer.

M. Do not install firestop products when substrates are wet due to rain, frost, condensation or other causes.

N. Schedule installation of firestopping after completion of penetrating item installation but prior to covering or concealing openings.

O. Firestopping devices shall not act as supports.
## EQUIPMENT SCHEDULE - FS

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<td>CABLE PATHWAY FIRESTOPPING DEVICE</td>
<td>EZ-Path</td>
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END OF SECTION
SECTION 27 04 06
COMMON WORK - HANGERS AND SUPPORTS

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes specific requirements for hangers and supports within the Communications Pathway System. General requirements are covered in Division 27 Specification Section Electrical - General Requirements.

1.2 RELATED SECTIONS
A. The requirements of Division 27 Specification Section Electrical - General Requirements shall serve as the basis for the requirements of this Section, and are incorporated by reference into this Section.

1.3 SUBMITTALS
A. Provide the following per the criteria set forth in Submittals in Division 27 Specification Section Basic Communications Requirements:
   1. Product Data

1.4 DEFINITIONS
A. Hanger/Support System: All equipment, materials, and incidentals required to support the raceway/pathway and cabling systems, including but not limited to metallic hangers and supports, conduit, cable tray, conduit, pull boxes, device boxes, u-channels, threaded rods, clamps, concrete inserts, anchor bolts, cables, backing boards, etc.

PART 2 - MATERIALS

2.1 GENERAL
A. Part Numbers: Refer to the equipment schedule at the end of this Section for specific part numbers. If no part number is provided, then any part meeting the requirements and manufacturers specified is acceptable.

2.2 HANGERS AND SUPPORTS
A. A complete Hanger/Support System shall be provided to support all components of the raceway/pathway and cabling systems.
B. The Contractor shall provide all materials, labor and incidentals as required for a complete Hanger/Support System.
C. The Hanger/Support System shall be of corrosion resistant or galvanized steel, shall be of an approved standard design, and shall be constructed to maintain the supported load in proper position and alignment under all operating conditions. Manufacturer shall be:
   1. B-line
   2. Caddy/Erico
   3. Kindorf
   4. Unistrut
   5. or Equal
2.3 Cable Supports (Straps)

A. Cable supports shall only be permitted where shown on Drawings.

B. Cable straps within Communications Equipment Rooms:
   1. Cable Straps shall be used within communications rooms and spaces and shall be provided for strapping groups of cables to raceway and for controlling/managing patch cables. The use of plastic tie wraps for this purpose is not acceptable. Cable straps shall be self-gripping, reusable, constructed of Velcro, and hook-and-loop style. Cable straps to be used in plenum air handling spaces shall be plenum rated. Cable straps shall be manufactured by:
      a. Hubbell
      b. Velcro
      c. Approved Equal
   2. Size: Cable strap size shall be:
      a. For Patch Cables: ½ inch wide and minimum 8/maximum 12 inches in length.
      b. For Horizontal Cables: ½ inch wide and minimum 8/maximum 12 inches in length.
      c. For Backbone Cables: ¾ inch wide and minimum 12/maximum 18 inches in length.
   3. Color: Cable strap color shall be the same color as the cable color of the bundle to be strapped, unless noted otherwise in the Equipment Schedule at the end.

PART 3 - EXECUTION

3.1 Hangers and Supports

A. Hanger/Support system shall be installed in such a manner as to prevent any strain being imposed on the equipment supported.

B. Coordinate with the building structure and the work of other trades.

C. Install individual and multiple trapeze raceway hangers and riser clamps as necessary to support raceways. Provide all incidental materials as necessary for hanger assembly and for securing hanger rods and conduits. Use 3/8 inch diameter or larger all-thread rods for support.

D. Hangers and supports shall be installed at intervals in compliance with NEC requirements.

E. Strength of each support shall be adequate to support a minimum of five times the present and future load. A minimum of 200 pound safety allowance for each support is required.

F. Cut threaded rods such that the bottoms have a maximum length of thread below the bottom nut equal to that of the rod diameter (i.e. a 3/8 inch rod would have a maximum length of 3/8 inches below the bottom nut).

G. Conduit and box support installation shall prevent displacement of conduit and box in any direction.

H. Provide plastic or rubber end caps for all Hanger/Support System components which are readily accessible and exposed to personnel.

I. Anchor Methods:
   1. Hollow Masonry: Toggle bolts or spider type expansion anchors.
   3. New Concrete: Preset inserts with machine screws and bolts.
   4. Existing Concrete: Steel expansion bolts or explosive powder driven inserts.
   5. Wood surfaces: Wood screws.
   6. Steel: Welded threaded studs or galvanized steel clamps.
   7. Light Steel: Sheet metal screws.

J. Firestopping devices shall not act as supports.
3.2 CABLE SUPPORTS (STRAPS)

A. All cabling shall be supported by conduit from device box to pull box or cable tray.

B. Exterior to Communications Equipment Rooms:
   1. Where cable pathways are shown on the Drawings, the Contractor shall follow the indicated pathways as closely as possible, subject to field conditions. Pathways, where not shown, including pathways for small cable counts, shall be designed and documented on the As-built drawings maintained by the Contractor.

C. Within Communications Equipment Rooms:
   1. Install Screw-Mount, Reusable Cable Ties on the equipment racks and where required by UCB.
   2. Install cable straps to secure cable bundles (see below) to cable runway and other supporting equipment. The use of plastic tie wraps for this purpose is not acceptable.
      a. Bundling:
         1) Cables shall be bundled by application (patch, horizontal, backbone) and by cable type (Cat 3, Cat 5E, Cat 6, Cat 6a, MM Fiber, SM Fiber, etc.). Cable applications and types shall not be intermixed within a bundle.
         2) Cable bundles (of a given application and cable type) shall consist of relatively even cable quantities.
      b. Quantity of cable per cable bundle shall be as follows:
         1) For Patch Cables: 24 to 48 patch cables per cable bundle with straps applied at 1 foot intervals.
         2) For Horizontal Cables: 50 to 100 horizontal cables per cable bundle with straps applied at 3 foot intervals.
         3) For Backbone Cables: 4 to 8 backbone cables per cable bundle with straps applied at 3 foot intervals.
      c. Provide excess cable straps to Owner.
### EQUIPMENT SCHEDULE - JS

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END OF SECTION
SECTION 27 05 00
ELECTRICAL - GENERAL REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes general requirements for raceway, pathways, grounding and bonding, and other electrical infrastructure necessary for the support of communications systems.

1.2 RELATED SECTIONS
A. The requirements of this Section are additional to, different from, or otherwise supplement similar Section(s) in Division 26. The applicable requirements of those Section(s) shall serve as the basis for the requirements of this Section, and are incorporated by reference into this Section.

B. Division 27 Specification Section Common Work - Sleeves, Penetrations and Firestopping. Provide sleeves, penetrations, and firestopping as required to support the work of this Section.

C. Division 27 Specification Section Common Work – Hangers and Supports. Provide hangers and supports as required to support the work of this Section.

1.3 SUBMITTALS
A. Provide the following per the criteria set forth in Submittals in Division 27 Specification Section Basic Communications Requirements:
   1. Product Data
   2. Shop Drawings:
      a. Raceway/pathway routing plan (including underslab, underfloor, and OSP conduit/ducts):
         1) Provide a routing if such plan has not been shown on the Drawings, or if the Contractor is proposing a deviation from that shown. The routing plan shall include:
            a) Complete floor plans or detail drawings showing the proposed routing and raceway sizes and locations, submitted in a manner equal to that of the Construction Drawings.
            b) A statement that the proposed routing has been coordinated with electrical, HVAC, plumbing, and other trades, and that comparable changes have been made to the cabling systems making use of the routing. Specifically note each location where the proposed routing is different from the Drawings, and the reason for the deviation.
            c) Routing deviations must be approved in writing by the Engineer prior to proceeding with installation.
         2) If a routing plan is not required, submit written documentation stating that:
            a) The raceway/pathway routing will be provided as shown on the Drawings,
            b) The Contractor has reviewed the routing shown on the Drawings with the other applicable trades and that it does not create conflicts between the trades
            c) The raceway/pathway routing meets applicable codes, regulations and standards.
   3. Other:
      a. Owner Specific: Submit other information as required by Owner Specific Governing Requirements in Specification Section Basic Communications Requirements.

PART 2 - MATERIALS

2.1 THIS SECTION NOT USED
PART 3 - EXECUTION

3.1 GENERAL

A. Work shall comply with the Governing Requirements as defined in Division 27 Specification Section Basic Communications Requirements. Governing Requirements of particular relevance to this Section include, but are not limited to:

1. NEC: National Electrical Code (NFPA Article 70)
2. TIA/EIA 569: Commercial Building Standard for Telecommunication Pathways and Spaces
3. TIA/EIA 606: The Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
4. ANSI J-STD-607: Commercial Building Grounding and Bonding Requirements for Telecommunications

B. Installation shall be such that communications circuits, when installed in the pathway systems specified herein, are able to fully comply with the following:

1. TIA/EIA 568: Commercial Building Telecommunications Cabling Standard

C. The Contractor shall pay particular attention to and comply with the following Owner Governing Requirements:

1. University of Colorado at Boulder:
   a. UCB Telecommunications Standards: (http://www.colorado.edu/facilitiesmanagement/pdc/construction/standards/documents/Division27CommunicationsSpecifications.pdf)
   b. UCB Construction Inspection Report
   c. UCB Construction Drawings As-Built Requirements

D. Telecommunications pathways shall be dedicated for use for telecommunications cabling only. No other type of cabling (e.g. intercom, audio, video, security, fire, etc.) may be placed in telecommunications pathways without prior written Owner approval.

E. Unless otherwise noted on the Drawings or specified herein, communications raceway/pathways (conduit, sleeves, cable tray, surface raceway, etc.) shall be sized according to the quantity and outside diameter of the cable(s) they are to support per NEC fill ratios and TIA/EIA 569 cable capacity standards, plus an additional 25 percent for future expansion.

F. Firestopping: All penetrations of fire rated barriers shall be firestopped and sealed. The fire rating of all fire barriers shall be strictly maintained.

G. Labels/identification: Label and identify components of the pathway system per TIA/EIA 606.

END OF SECTION
SECTION 27 05 26
ELECTRICAL TECHNOLOGY - GROUNDING AND BONDING

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes specific requirements for the Telecommunications Bonding Infrastructure to provide a permanent bonding infrastructure for communications systems.

B. The Telecommunications Bonding Infrastructure is bonded to the building grounding system and performance is dependent upon the building grounding system – the AC Electrode Grounding System and the Equipment Grounding System specified in Division 26 Specification Grounding and Bonding.

C. General requirements are covered in Division 27 Specification Section Electrical - General Requirements.

1.2 RELATED SECTIONS
A. The requirements of Division 27 Specification Section Electrical - General Requirements shall serve as the basis for the requirements of this Section, and are incorporated by reference into this Section.

B. The requirements of Division 26 Specification Section Grounding and Bonding shall serve as the basis for the requirements of this Section, and are incorporated by reference into this Section.

C. This Section may expand upon or supplement the requirements of Division 26 Specification Section Grounding and Bonding. In the event of a conflict or discrepancy between this Section and the requirements of Division 26 Specification Section Grounding and Bonding, the requirements of Division 26 Specification Section Grounding and Bonding shall govern and notification of such discrepancy shall be submitted to the Engineer. However, if the requirement of this Section (or portion thereof) exceeds that of the requirements of Division 26 Specification Section Grounding and Bonding, and is furthermore not contrary to the requirements of Division 26 Specification Section Grounding and Bonding, then the requirement of this Section (or portion thereof) shall prevail.

1.3 SUBMITTALS
A. Comply with the Submittal portion of Division 27 Specification Section Basic Communications Requirements. Provide submittal information for the following:
   1. Product Data

1.4 DEFINITIONS
A. BCT: Bonding Conductor for Telecommunications: Conductor that bonds the TMGB to the AC Grounding Electrode System.

B. EF: Entrance Facility: Entrance to a building for both public and private network service cables. May be located in an ER or TR.

C. ER: Equipment Room: Environmentally controlled centralized space of telecommunications equipment. Sometimes referred to as Main Distribution Frame (MDF), Data Center (DC), or server room.

D. GE: Grounding Equalizer: Bonding conductor that bonds TGBs on the same floor of a structure.
E. TBB: Telecommunications Bonding Backbone: Bonding conductor that bonds the Telecommunications Main Grounding Busbar to one or more Telecommunications Grounding Busbars.

F. TE: Telecommunication Enclosure: Floor or tenant serving space (enclosure or cabinet) that provides a connection point between backbone and horizontal infrastructures. Sometimes referred to as an Intermediate Distribution Frame (IDF) or Floor Distributer (FD).

G. TEBM: Telecommunications Equipment Bonding Conductor: Bonding conductor that bonds all non-current carrying metal telecommunications equipment and materials to the nearest TGB or TMGB.

H. TGB: Telecommunications Grounding Busbar: Busbar used to connect TEBMs and TBBs in a specific room. TGB is generally connected (bonded) to building structural steel, the nearest low-voltage electrical distribution panel and to the Telecommunications Main Grounding Busbar via the TBB. There is typically one (possibly more) Telecommunications Grounding Busbar per telecommunication room or equipment room.

I. TMGB: Telecommunications Main Grounding Busbar: Busbar bonded to the electrical service ground (Intersystem Bonding Termination). Origination of the TBB. There is typically one Telecommunications Main Grounding Busbar per building, located in near the communications entrance facility (EF) or in the main telecommunications room (MDF) or Building Distributer (BD).

J. TR: Telecommunication Room: Floor or tenant serving space that provides a connection point between backbone and horizontal infrastructures. Sometimes referred to as an Intermediate Distribution Frame (IDF) or Floor Distributer (FD).

**PART 2 - MATERIALS**

2.1 **GENERAL**

A. Manufacturer: Communications grounding and bonding equipment and materials shall be manufactured by a single Manufacturer unless specifically stated otherwise. The manufacturer shall be:

1. Chatsworth Products, Inc. (CPI)

B. Part Numbers: Refer to the equipment schedule at the end of this Section for specific part numbers. If no part number is provided, then any part meeting the requirements specified is acceptable.

C. Labels/Identification: Provide labels to identify all components of the communications grounding and bonding system. Labels shall be permanent (i.e. not subject to fading or erasure) and permanently affixed. Handwritten labels are not acceptable.

D. Equipment and materials in this Section shall be UL Listed and Labeled.

2.2 **GROUNDING BUSBARS**

A. Grounding busbars shall meet the specifications of ANSI J-STD-607 and conform to BICSI recommendations, with standard NEMA bolt hole sizing. Grounding busbars shall be predrilled copper busbars plated for reduced contact resistance and have minimum dimension of 1/4 inch thick by width and length listed below:

1. Telecommunications Main Grounding Busbar (TMGB): TMGB’s shall be a minimum of 4 inches wide and have a minimum length of 20 inches. Provide busbar with required quantity of two-hole lugs for application. Provide as shown on the Drawings. Where not shown, provide one TMGB per primary telecommunications room (e.g. EF, ER, etc.).
2. Telecommunications Grounding Busbar (TGB): TGB’s shall be a minimum of 2 inches wide and have a minimum length of 10 inches. Provide busbar with required quantity of two-hole lugs for application. Provide as shown on the Drawings. Where not shown, provide a minimum of one TGB per secondary communications room (e.g. TE, TR, ER, etc.).

2.3 BCT

A. Provide insulated green, insulated green with yellow strip, or un-insulated - copper conductor properly sized according to length of conductor and size of AC Grounding Electrode Conductor for the electrical service per NEC, TDMM, and IAEI calculations.

2.4 TBB

A. Provide insulated green, insulated green with yellow strip, or un-insulated - copper conductor. Unless otherwise noted on the Drawings, conductors shall be sized according to conductor length as follows:
1. Less than 13 feet: #6 AWG
2. 13 to 20 feet: #4 AWG
3. 20 to 26 feet: #3 AWG
4. 26 to 33 feet: #2 AWG
5. 33 to 44 feet: #1 AWG
6. 44 to 52 feet: #1/0 AWG
7. 52 to 66 feet: #2/0 AWG
8. Greater than 66 feet: #3/0 AWG

2.5 TEBC

A. Provide insulated green or insulated green with yellow strip - 6 AWG copper conductor not to exceed 100 feet in length.

PART 3 - EXECUTION

3.1 GENERAL

A. Work shall comply with the Governing Requirements as defined in Division 27 Specification Section Basic Communications Requirements. Governing Requirements of particular relevance to this Section include, but are not limited to:
1. ANSI J-STD-607: Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications
2. NEC: National Electric Code (NFPA Article 70)
3. UL 467: Grounding and Bonding Equipment

B. Contractor shall ensure that positive bonding connections are made to bare metallic surfaces, equipment, materials and hardware by removing surface corrosion, oxidation and paint prior to connection.

C. Where possible, bonds to structural steel shall be exothermic.

D. Where possible, exothermic or irreversible compression-type connections and two-hole lugs shall be used to terminate bonding conductors.

E. Labels/Identification: Label and identify all components of the communications grounding and bonding system.
3.2 GROUNDING BUSBARS:

A. Arrange telecommunication primary and secondary protector bonding, busbar bonding (e.g., BCT, GE, TBB, etc.) and approved building grounding conductors (e.g., toward the left, leaving space for equipment bonding conductors (e.g., TEBC, etc.) to the right.

1. TMGB:
   a. Directly bond TMGB to:
      1) Building structural steel (if building structural steel is approved building grounding system) via bonding conductor sized per BCT calculations – minimum size of 2/0 AWG copper conductor.
      2) Intersystem Bonding Termination via BCT if BCT is less than 30 feet in length or if BCT length is shorter than bonding conductor length to nearest low-voltage electrical distribution panel.
      3) Nearest low-voltage electrical distribution panel if Intersystem Bonding Termination is not available.
      4) TGB’s via TBB’s as shown on drawings.
   b. Label with “TMGB”.

2. TGB:
   a. Directly bond TGB to:
      1) Building structural steel (if building structural steel is approved building grounding system) via bonding conductor sized per BCT calculations – minimum size of 2/0 AWG copper conductor.
      2) Nearest low-voltage electrical distribution panel
      3) TMGB via TBB’s as shown on drawings.
      4) TGB’s via TBB’s as shown on drawings.
      5) TGB’s via GE’s as shown on drawings.
      6) Telecommunications equipment and materials via TEBC’s.
   b. Label with “TGB”.

3.3 GE

A. GE’s shall be used to connect TGB’s to other TGB’s on designated floors. Route along the shortest and straightest path possible with minimal bends. Bends shall be sweeping. GE’s shall be continuous (without splices), and shall be insulated from their support.

B. Label with “WARNING! TELECOMMUNICATIONS GROUNDING EQUALIZER (GE). DO NOT REMOVE OR DISCONNECT!” Labels shall be affixed at both ends and at accessible intermediate points.

3.4 TBB

A. TBB’s shall be used to connect the TMGB to each TGB and TGB to TGB. Route along the shortest and straightest path possible with minimal bends. Bends shall be sweeping. TBB’s shall be continuous (without splices), and shall be insulated from their support.

B. Label with “WARNING! TELECOMMUNICATIONS BONDING BACKBONE (TBB). DO NOT REMOVE OR DISCONNECT!” Labels shall be affixed at both ends and at accessible intermediate points.

3.5 TEBC

A. TEBC’s shall be used to bond all non-current carrying metal telecommunications equipment and materials to the nearest TGB. Route along the shortest and straightest path possible with minimal bends. Bends shall be sweeping. TEBC’s shall be continuous (without splices), and shall be insulated from their support.
B. Label with “WARNING! TELECOMMUNICATIONS EQUIPMENT BONDING CONDUCTOR (TEBC). DO NOT REMOVE OR DISCONNECT!” Labels shall be affixed at both ends and at accessible intermediate points.

3.6 QUALITY ASSURANCE AND TESTING

A. Visual inspection and correction of:
   1. Loose connections
   2. Corrosion
   3. Physical damage
   4. System modifications
   5. Correct and visible labeling

B. Test Integrity of Bonding Connections
   1. Perform two-point bonding measurements using an earth grounding resistance tester configured for continuity test per manufacturer’s recommendations setup and safety precautions.
      a. Measure between TMGB or TGB and nearest available grounding electrode (e.g., structural steel). Maximum value between two points shall be 0.1 ohm.
      b. Measure between equipment, equipment racks, ladder racks, rack grounding busbars and TMGB or TGB. Maximum value between two points shall be 0.1 ohm.
      c. Bonding resistance between any two conductive points in the EF, ER, TE, or TR shall not exceed 0.1 ohms.
   2. Forward copy of test results to Engineer.
## EQUIPMENT SCHEDULE - GB

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**END OF SECTION**
PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes specific requirements for conduits and boxes within the Communications Pathway System. General requirements are covered in Division 27 Specification Section Electrical - General Requirements.

1.2 RELATED SECTIONS
A. The requirements of Division 27 Specification Section Electrical - General Requirements shall serve as the basis for the requirements of this Section, and are incorporated by reference into this Section.

1.3 SUBMITTALS
A. Comply with the Submittal portion of Division 27 Specification Section Basic Communications Requirements. Provide submittal information for the following:
   1. Samples:
      a. Provide one full size installation sample/mock-up for each of the following components. All samples are to be fully labeled per the Specifications and shall be complete with all associated components necessary to make a complete mock-up. Samples will be used to set the standard for the quality of work required of the Contractor throughout the project. Installation work not meeting the sampled standard will be rejected and shall be replaced by the Contractor at no additional cost to the Owner.
         1) Outlet box: Provide a mock-up of the box assembly. The sample assembly shall be complete with box, extension ring, mudring, and a 12 inch length of conduit.

1.4 DEFINITIONS
A. EMT: Electrical Metallic Tubing
   B. RMC: Rigid Metal Conduit
   C. RNC: Rigid Nonmetallic Conduit
   D. IMC: Intermediate Metal Conduit

PART 2 - MATERIALS

2.1 GENERAL
A. Part Numbers: Refer to the equipment schedule at the end of this Section for specific part numbers. If no part number is provided, then any part meeting the requirements specified is acceptable.

2.2 CONDUIT
A. Conduit types:
   1. EMT shall be steel, hot-dipped galvanized or electro-galvanized, with an inner coating to protect cables and aid pulling, UL listed, and meeting the requirements of UL 797 and ANSI C80.3.
2. RMC shall be steel, hot-dipped galvanized inside and outside with factory threaded ends full cut and galvanized after threading, UL listed, and meeting the requirements of UL 6 and ANSI C80.1.

3. RNC shall be PVC Schedule 40 rigid plastic unless otherwise noted on the Drawings, shall be rated for use with 90 degree C wire, and shall conform to UL 651, WC-1094C and NEMA TC 2. Only RNC shall be used in concrete floors without prior written permission from Engineer or Owner.

4. RNC Type EB-20 shall be provided as shown on the drawings, shall be ETL listed, tested to UL-651-A, and shall meet the requirements of NEMA TC-6 and ASTM F-512.

5. Flexible (flex) conduit: Flex conduit is not approved and not acceptable. Where, in rare instances, flex conduit is the only remaining viable raceway option, the Contractor shall notify the Engineer and await the Engineer’s direction prior to procurement and installation.

6. Condulets (LB’s): Condulets (LB’s) are not approved and are not acceptable.

B. Fittings:
   1. Provide fittings as follows:
      a. EMT fittings shall be steel compression type with a nylon insulated throat for rain-tight and concrete-tight applications, steel set screw type or steel compression type for all other connections. Conduit ends shall be fitted with bushings – bushings shall be threaded and have a nylon insulated throat.
      b. RMC fittings shall be threaded galvanized steel. Conduit ends shall be fitted with bushings – bushings shall be threaded and have a nylon insulated throat.
      c. RNC fittings shall be of same material and manufacturer as the conduit, shall be UL listed and conform to UL 514. Cement shall be as recommended by manufacturer.

   2. Expansion fittings shall be provided across structural joints, shall be of a design to compensate for expansion and contraction, shall be sealed to prevent entrance of water and moisture, and shall safely deflect and expand up to twice the distance of the structural movement. Expansion fittings shall be approved for grounding duty.

2.3 JUNCTION BOXES

A. Junction boxes shall be provided to serve as a transition point between pathways/raceways. Junction boxes shall be galvanized stamped steel, deep drawn one piece (without welds or tab connections), with knockouts for conduit entrances, meeting NEMA OS 1.

B. Junction boxes in walls:
   1. Unless otherwise shown on the Drawings, junction boxes shall be minimum 4 inch by 4 inch, with extension ring, single gang mud ring, and knockouts pre-manufactured to support the conduit size serving the junction box (i.e. field modifications of the junction boxes to support the conduit sizes specified are not acceptable). Combined depth of junction box and extension ring shall be a minimum 3-1/2 inches.

2.4 OUTLET BOXES

A. Outlet boxes shall be provided to house communications outlets/connectors. Outlet boxes shall be galvanized stamped steel, deep drawn one piece (without welds or tab connections), with knockouts for conduit entrances, meeting NEMA OS 1, and with extension rings to suit construction and application.

B. Unless otherwise shown on the Drawings, outlet boxes shall be minimum 4 inch by 4 inch, with extension ring, single gang mud ring, and knockouts pre-manufactured to support the conduit size serving the outlet box (i.e. field modifications of the outlet box to support the conduit sizes specified are not acceptable). Combined depth of outlet box and extension ring shall be a minimum 3-1/2 inches.

C. Outlet boxes in modular furniture locations shall be deep device boxes.
2.5 PULL BOXES

A. Pull Boxes shall be code gauge sheet metal/fabricated steel continuously welded at seams and painted after fabrication. Boxes shall be complete with covers, trim, etc.

B. Minimum pull boxes sizes shall be as follows:

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C. Pull Boxes for conduits sized larger than shown in the table above shall be provided as shown on the Drawings.

2.6 FLOOR BOXES

A. Floor boxes shall provide the interface for power, communication and/or audio/visual cabling in an above grade floor. Floor boxes shall be flush style, shall exceed UL scrub water exclusion requirements for tile and carpet floors, and shall be complete with covers, brackets and hardware to support installation as shown on Drawings.

1. Floor boxes may be combined for use by both power and communications where shown on the Drawings. When combined, provided metal dividers separating power from communications and provide separate conduits for power and communications.

2. Floor boxes shall be complete with brackets, cover plates, and/or other means to support power, communications, and/or audio-visual type connectors shown on the Drawings or called for in the Specifications.

B. Floor Box Types:

1. Floor Box (4-gang): Floor boxes shall be in a recessed box, shall be adjustable before concrete pour, and shall be complete with brackets to support power, communications, and/or audio/visual type connectors as shown on the Drawings and specified in Specifications.

2. Deep Floor Box (11-gang): Floor boxes shall be in a recessed box, shall be adjustable before concrete pour, and shall be complete with brackets to support power, communications, and/or audio/visual type connectors as shown on the Drawings and specified in Specifications.

3. Floor Box (Flexible Conduit): Floor boxes shall be in a recessed box, shall be adjustable before concrete pour, and shall be complete with pans and brackets to support power, communications, and/or audio/visual type connectors as shown on the Drawings and specified in Specifications. Floor boxes shall be equipped with flexible conduit as required to interface into furniture. Floor boxes shall be approximately 7.5 inches x 7.38 inches by 3.5 inches deep, not including PVC riser. Pour pans shall be provided as required. Floor boxes shall be UL listed. Covers for floor boxes shall be included and shall support flexible conduit to furniture, as required. Covers shall be coordinated with Architect.
C. Floor Box Covers: Covers shall be provided for each floor box, and shall be coordinated with Architect.

2.7 WALL BOXES

A. Wall boxes shall provide the interface for power, communication and/or audio/visual cabling within walls. Wall boxes shall be flush style and shall be complete with covers, brackets and hardware to support installation as shown on Drawings.

1. Wall boxes may be combined for use by both power and communications where shown on the Drawings. When combined, provided metal dividers separating power from communications and provide separate conduits for power and communications.

2. Wall boxes shall be complete with brackets, cover plates, and/or other means to support power, communications, and/or audio-visual type connectors shown on the Drawings or called for in the Specifications.

PART 3 - EXECUTION

3.1 CONDUIT

A. General:

1. Run conduit in the most direct route possible, parallel and perpendicular to building lines.

2. Route conduits as close to structure as possible.

3. Do not route conduit through areas in which flammable material may be stored, or over or adjacent to boilers, incinerators, hot water lines, or steam lines.

4. Conceal all conduit unless indicated otherwise, within finished walls, ceilings, and floors.

5. Keep conduits at least 6-inches away from parallel runs of flues and steam or hot water pipes.

6. Install conduits level and square and at proper elevations.

7. For conduit runs exceeding more than 100 feet in length, provide pull boxes (see Part 3 – Execution, Pull Boxes herein) so that no conduit segment between end points/pull boxes exceeds 100 feet.

8. For conduit runs which require more than two 90 degree bends, install pull boxes (see Part 3 – Execution, Pull Boxes herein) so that no conduit segment between end points/pull boxes contains more than two 90 degree bends.

9. Ream all conduits to eliminate sharp edges. Conduits shall be reamed after threads are cut.

10. Joints shall be cut square and shall butt solidly into couplings.

11. Terminate all metal conduits with metallic threaded insulated throat bushings, PVC conduit with PVC bushings.

12. Metallic conduits entering communication rooms shall be equipped with grounding lugs.

13. Prevent foreign matter from entering conduits by using temporary closure protection. After cable installation, cap each unused conduit with a mechanical-type seal (tape is not acceptable).

14. Conduits shall be installed in such a manner as to keep exposed threads to an absolute minimum and in no case shall more than three threads be left exposed.

15. Install expansion fittings where conduit crosses an expansion join in structure or is in an environment where temperature changes combined with conduit run length may produce expansion or contraction stress. Provide a flexible bonding jumper at least three times the nominal width of the joint.

16. Terminate conduits that protrude through a floor 1 to 3 inches above the surface of the floor.

17. Conduits shall be cleaned and dried prior to the installation of cables.

18. Route conduit through roof openings for piping and ductwork wherever possible. Where not possible, provide and route through roof jack with pitch pocket for waterproofing. Empty conduits passing through roof penetrations shall be capped and sealed weather tight.
19. Conduits passing through exterior walls and floors below grade shall be made watertight with duct plugs. Pipe sleeves and wall collars shall extend all around the conduit or entrance seals and be specifically manufactured for that purpose.

20. When using RNC, transition to RMC for all bends, stub-ups, and penetrations through foundation walls.

B. Conduit Schedule:
1. Buried or below grade level slab: RNC
2. Embedded in concrete slab: RNC
3. Through foundation walls: RMC
4. Corrosive/Hazardous Areas: RMC
5. Exposed or subject to mechanical injury: RMC
6. All other areas (unless otherwise noted): EMT

C. Minimum Conduit Sizing, where not shown on the Drawings:
1. Outlet Boxes: 1 inch
2. Junction Boxes in walls: 1 inch
3. Floor boxes: Provide per the Drawings. Where not shown, coordinate with the other Trades who will make use of the floor box and provide per their requirements. Conduits shall be provided per the manufacturer’s requirements and recommendations for the specified floor box.

D. Conduit bends:
1. A conduit bend shall not exceed 90 degrees and shall not be constructed in such a way as to reduce the effective diameter of the conduit.
2. Conduit bends shall be sweeping, shall conform to TIA/EIA 569 bend radius requirements, and shall be a minimum of no less than 10 times the internal diameter of the conduit.
3. For conduits larger than 1-1/4 inch, bends shall be factory-manufactured. Bending conduit larger than this in the field using manual or mechanical methods is not acceptable. 1 inch and 1-1/4 inch bends shall be made in an approved bending machine or shall be factory-manufactured.
4. The contractor shall test each conduit with a mandrel to prove compliance with TIA/EIA and cable manufacturer bend radius requirements throughout the conduit run and shall provide evidence of such testing immediately upon request of the Engineer.
5. The sum total of conduit bends for a conduit segment between end points/pull boxes shall not exceed 180 degrees, except one additional bend of up to 90 degrees is acceptable if the bend is located within 12 inches of the cable feed end.
6. 90 degree condulets (LB’s) are not acceptable.

E. Conduit/duct runs under slab: Coordinate with other trades (electrical, plumbing, etc.) prior to trenching and installation. Communications conduit/duct runs under slab shall not share a trench with conduit/duct runs from other trades.

F. Conduits embedded in slab: Not acceptable unless otherwise shown on the Drawings.

G. Pull Strings:
1. Equip all conduits over 3 feet long with plastic or nylon pull strings with printed footage indicators and a minimum test rating of 200 pounds. Extend pull string a minimum of 3 feet from each end. Pull strings shall be secured to avoid losing the pull string within the conduit by either securing tying the end of each string in place, or by tying the end of each string to a washer with a diameter larger than the conduit diameter.
2. Label each pull string in a clear manner by designating, at each end of the pull string, the location of the far end of the pull string (i.e. room name, communications closet name, pull box identifier, cable tray, station identifier, etc. Indicate pull string length on the label.
H. Bushings: The Contractor is solely responsible for ensuring that bushings (insulated throat for metallic conduit, PVC for PVC conduit) are installed at conduit end(s) prior to cable installation. Where cable is installed prior to the installation of bushings, the Contractor shall remove the cable, install the bushing, and re-install the cable at no additional cost to the Owner.

I. Labels: Label each conduit end in a clear manner by designating, at each end of the conduit, the location of the far end of the conduit (i.e. room name, communications closet name, pull box identifier, cable tray, station identifier, etc.). Indicate conduit length on the label.

3.2 JUNCTION AND OUTLET BOXES

A. General:
   1. Unless otherwise indicated, boxes shall be recessed. Set boxes plumb, level, square and flush with wall. Do not exceed more than 1/16 inch tolerance for each condition. Recess outside edge and trim plates from finished surface in accordance with NEC.
   2. Unless shown otherwise on Drawings, outlet boxes shall be fed with conduit to cable tray.
   3. Boxes shall be supported independently of the conduit system. Supports shall be noncombustible and corrosion resistant. Suspended boxes shall be supported with threaded rod hangers and galvanized steel clamps, or trapeze hangers such as Unistrut.
   4. Box locations may be adjusted by the Engineer by up to 10 feet from the location shown on the Drawings at no additional cost to the Owner.
   5. Install additional straps or cross-bracing to ensure a rigid installation in a steel stud system.
   6. Boxes on opposite sides of fire rated walls and partitions shall be separated by a horizontal distance of at least 24 inches.
   7. Unused knockouts in boxes shall be left sealed.
   8. For acoustical purposes, boxes on opposite sides of a wall shall not be located back-to-back.
   9. For boxes to be installed in brick, masonry or concrete, offsets shall be provided to provide for proper adjustment to finished surfaces. Exposed mortar is not acceptable around device plates.
   10. In the event of discrepancies between box locations shown on the Communications drawings and any other drawings in the Construction Documents, the Contractor shall notify the Engineer and await the Engineer’s direction prior to installation.

B. Device Box Types
   1. Outlets:
      a. Unless specifically noted otherwise on the Drawings, outlet boxes shall be dedicated to communications, and shall not be shared with power. Furthermore, the use of dividers to divide a single box into “separate” sections for communications and power (or another function) is not acceptable.
      b. Outlet boxes shall be located within 3 feet of an electrical power receptacle. Where conditions are such that this is not possible, promptly notify the Engineer and await the Engineer’s direction prior to rough-in of the box.

3.3 PULL BOXES

A. Install pull boxes in an exposed location, readily accessible both at time of construction and after building occupation. Pull boxes shall not be installed in interstitial or otherwise non-accessible building spaces.

B. If mounting a pull box on ceiling structure above ceiling grid, do not mount higher than 4 feet above grid (mount on wall instead).

C. Install pull boxes such that conduit enters and exits only from opposite ends of the box (i.e. only two sides of a box may be used for conduit entry and those two sides must be opposite one another).
D. Do not install conduits into pullboxes in such a manner as to obstruct the installation of future feeder conduits into or out of the pullbox.

E. A pull box shall not be substituted for a 90 degree bend.

F. Do not exceed one pull box per total conduit run between outlet box and termination point in a communications closet, unless otherwise shown on the Drawings. Where field conditions necessitate the use of additional pull boxes notify the Engineer and await the Engineer's direction prior to procurement and installation.

G. Pull boxes shall be rigidly mounted. Unused knockouts shall be plugged with suitable blanking devices.

H. Labels: Label each pullbox with a unique identifier. Identifiers shall be of the form “RN-YY” where “RN” is the room name of the room closest to (or containing) the pull box, and “YY” is the sequential number of the pull box for each “RN”. For example: The second pull box in the vicinity of room “201” would have the label “201-02”.

3.4 FLOOR BOXES

A. Set boxes plumb, level, square and flush with floor. Do not exceed more than 1/16 inch tolerance for each condition.

B. Floor boxes shall have been tested for use in fire-resistance-rated assemblies applicable to the condition(s) present in Project, and shall be installed in accordance with the instructions included in the listing.

C. For floor boxes installed in concrete slab:
   1. Coordinate floor boxes with slab/concrete topping depth. Where depth of floor box conflicts with slab depth notify the Engineer and await the Engineer's direction prior to procurement and installation.
   2. Adjust box prior to and after concrete pour.

D. Covers shall be installed per manufacturer’s recommendations.

E. For floor boxes with combined power and communications circuits, install metal dividers for separation of circuits and provide separate conduits for power and communications.

3.5 WALL BOXES

A. Set boxes plumb, level, square and flush with floor. Do not exceed more than 1/16 inch tolerance for each condition. Recess outside edge and trim plates from finished surface in accordance with NEC.

B. Boxes shall be supported independently of the conduit system. Supports shall be noncombustible and corrosion resistant. Suspended boxes shall be supported with threaded rod hangers and galvanized steel clamps, or trapeze hangers such as Unistrut.

C. Box locations may be adjusted by the Engineer by up to 10 feet from the location shown on the Drawings at no additional cost to the Owner.

D. Install additional straps or cross-bracing to ensure a rigid installation in a steel stud system.

E. Boxes on opposite sides of fire rated walls and partitions shall be separated by a horizontal distance of at least 24 inches.

F. Unused knockouts in boxes shall be left sealed.

G. For acoustical purposes, boxes on opposite sides of a wall shall not be located back-to-back.

H. For boxes to be installed in brick, masonry or concrete, offsets shall be provided to provide for proper adjustment to finished surfaces. Exposed mortar is not acceptable around device plates.
I. In the event of discrepancies between box locations shown on the Communications drawings and any other drawings in the Construction Documents, the Contractor shall notify the Engineer and await the Engineer’s direction prior to installation.

J. Covers shall be installed per manufacturer’s recommendations.

K. For wall boxes with combined power and communications circuits, install metal dividers for separation of circuits and provide separate conduits for power and communications.
## EQUIPMENT SCHEDULE - CB

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SECTION 27 05 36
ELECTRICAL - CABLE TRAYS

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes specific requirements for cable trays within the Communications Pathway System. General requirements are covered in Division 27 Specification Section Electrical - General Requirements.

1.2 RELATED SECTIONS
A. The requirements of Division 27 Specification Section Electrical - General Requirements shall serve as the basis for the requirements of this Section, and are incorporated by reference into this Section.

1.3 SUBMITTALS
A. Comply with the Submittal portion of Division 27 Specification Section Basic Communications Requirements. Provide submittal information for the following:
   1. Product Data

PART 2 - MATERIALS

2.1 GENERAL
A. Part Numbers: Refer to the equipment schedule at the end of this Section for specific part numbers. If no part number is provided, then any part meeting the requirements specified is acceptable.

2.2 CABLE TRAY SECTIONS AND COMPONENTS
A. General: Except as otherwise indicated, provide metal cable trays, of types, classes and sizes indicated. Cable tray shall be complete with all materials and incidental and miscellaneous hardware required for a complete cable tray system, including but not limited to support hangers, connector assemblies, clamp assemblies, connector plates, splice plates, bolts, nuts and washers for connecting units. Construct units with rounded edges and smooth surfaces; in compliance with applicable standards; and with the following additional construction features.
   B. Wire Basket Cable Tray System: Cable tray shall be “wire basket” type and shall be as follows:
      2. Width: Sized as shown on the drawings. Where not indicated on the Drawings, width shall be sized according to manufacturer’s recommendations for the amount of cable to be carried by the tray, plus an additional 100 percent for future expansion capability.
      3. Depth: 2 inch usable loading depth.
      4. Mesh: 2 inch by 4 inch mesh pattern with intersecting wires welded together.
      5. Fittings: Fittings shall be field fabricated through use of manufacturer’s hardware and in accordance with manufacturer’s instructions.
      6. Supports: Supports shall be “trapeze” style and provided in quantities as recommended by cable tray manufacturer according to maximum load. Supports shall mount under the tray and shall mount to tray in a “tool-less” fashion. Support hangers shall be 1/4 inch or 3/8 inch diameter rods.
      7. Load rating: NEMA 8A in accordance with NEMA VE 1.
8. Barrier strips: Provide cable tray sections with a single barrier for separation of telecommunications cabling from other low-voltage cables (such as CATV, security, etc.). Barriers shall be of same materials and finish as cable tray.
9. Grounding/bonding: Cable tray shall be complete with manufacturer’s hardware for grounding/bonding.
10. Seismic bracing: Provide to meet local codes.
11. Expansion fittings shall be provided across structural joints, shall be of a design to compensate for expansion and contraction, shall be sealed to prevent entrance of water and moisture, and shall safely deflect and expand up to twice the distance of the structural movement. Expansion fittings shall be approved for grounding duty.
12. Cable tray and all fittings and supports shall be manufactured by the same manufacturer.

PART 3 - EXECUTION

3.1 GENERAL
A. Install cable tray in the locations shown on the Drawings

3.2 INSTALLATION
A. Cable tray installation shall comply with manufacturer’s instructions/guidelines and NEMA VE 2- Cable Tray Installation Guidelines (latest edition).
B. Cable tray installed for communications circuit distribution may not be used for distributing electrical power. Cable tray installed for communications circuit distribution may not be used for distributing other signals without prior approval from the Engineer.
C. Prior to installation, examine areas to receive cable tray. Notify the Engineer/Owner of conditions that may adversely affect the installation, subsequent use, or cause the tray (or circuits to be subsequently installed in the tray) to not comply with TIA/EIA standards.
D. Coordinate layout and installation of cable tray with other construction elements and trades to ensure adequate headroom, working clearance and access.
E. Install cable tray level and plumb in accordance with the manufacturer’s recommendations, coordination drawings, original design, and referenced standards.
F. Utilize only manufacturer’s approved tooling for the installation of cable tray system.
H. Provide sufficient space encompassing cable trays to permit access for installing and maintaining cables.
I. Route cable tray as follows:
   1. Maintain a minimum clearance of 12 inches between top of cable tray and other elements such as ceiling structure, ducts, equipment, and other raceways. Where this is not possible, for very short distances (3 feet or less), a minimum clearance of 3 inches is acceptable. For longer distances, Contractor shall obtain the approval of the Engineer prior to installation.
   2. Maintain a clearance of 6 inch between bottom of cable tray and ceiling grid or other equipment or raceway.
   3. Maintain a working clearance of 12 inches between any one side of the cable tray and other equipment or barriers.
   4. Maintain a clearance of 4 feet from motors or transformers.
   5. Maintain a clearance of 1 foot from conduit or cables used for electrical power distribution.
   6. Maintain a clearance of 18 inches from fluorescent lighting.
7. Pathways shall cross perpendicular to fluorescent lighting and electrical power cables or conduits wherever possible.
8. Where cables in cable trays are required to maintain specific distances between each other, they shall be firmly secured to maintain this distance at fire rated penetrations.

J. Bends shall be long radius. Short radius bends and abrupt T-sections shall not be used unless specifically called out on the Drawings.

K. Seismic bracing: Brace cable tray to structure with diagonal braces spaced a maximum 30 feet on center or as is required per local codes.

L. Install barriers set at 6 inches from edge of cable tray. Barriers shall be on the same side of the cable tray for each run.

M. Cable tray supports shall be attached to the structural ceiling or walls with hardware or other installation and support aids specifically designed for the cable tray and designed to support the cable tray’s weight and required cable weight and volume.
   1. Do not attach cable tray supports to ceiling support system or other mechanical support systems.
   2. Load span criteria: Cable tray fitting supports shall be located such that they meet the strength requirements of straight sections for maximum load (based upon length, depth, and span). Install fitting supports per NEMA VE-2 guidelines, and in accordance with manufacturer’s instructions.

N. Connections: Tighten electrical connectors and joints according to manufacturer’s recommended torque-tightening values. Where such values are not indicated by the manufacturer, use those specified in UL 486A and 486B.

O. Cable tray shall be installed without burrs, sharp edges, or projections that may damage cable insulation. After installation, repair any damaged finishes.

P. Transition from cable tray to Cable Pathway Firestopping Devices at fire rated barriers and when penetrating communications rooms, and as otherwise shown on the Drawings.
   1. Provide Cable Pathway Firestopping Devices in sufficient quantity such that the combined useable volume of the devices is greater than or equal to the volume of cable tray to be served.

3.3 TESTING

A. Test cable tray system to ensure electrical continuity of bonding and grounding connections

B. Test for “worst case” loading conditions

C. Demonstrate compliance with NEMA VE-1

D. Demonstrate compliance with national and local codes.
## EQUIPMENT SCHEDULE - CT

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END OF SECTION
SECTION 27 05 43
ELECTRICAL - UNDERGROUND DUCTS AND RACEWAYS

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes general requirements for the Underground Ducts and Raceways for the Communications System. General requirements are covered in Division 27 Specification Section Electrical – General Requirements.

1.2 RELATED SECTIONS
A. The requirements of this Section are additional to, different from, or otherwise supplement the applicable requirements of Division 26. The applicable requirements of Division 26 shall serve as the basis for the requirements of this Section, and are incorporated by reference into this Section.

1.3 REFERENCES
A. In addition to the Governing Requirements, the applicable portion of the following shall be incorporated by reference into this Section:
   1. Concrete:
      a. Reinforcement:
         1) ACI 301: Structural Concrete for Buildings
         2) ACI SP-66: American Concrete Institute - Detailing Manual
         3) ANSI/ASTM A82: Cold Drawn Steel Wire for Concrete Reinforcement
         4) ANSI/AWS D1.4: Structural Welding Code for Reinforcing Steel
         5) ANSI/AWS D12.1: Reinforcing Steel Welding Code
         6) ASTM A615: Deformed and Plain Billet Steel Bars for Concrete Reinforcement
         7) AWS D12: Welding Reinforcement Steel, Metal Inserts and Connections in Reinforced Concrete Construction
      b. Cast-in-Place:
         1) ACI 212.3R: Chemical Admixtures for Concrete
         2) ACI 301: Structural Concrete for Buildings
         3) ACI 304: Recommended Practice for Measuring, Mixing, Transporting and Placing Concrete
         4) ACI 305R: Hot Weather Concrete
         5) ACI 306R: Cold Weather Concrete
         6) ASTM C33: Concrete Aggregates
         7) ASTM C39: Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
         8) ASTM C94: Ready-Mixed Concrete
         9) ASTM C150: Portland Cement
         10) ASTM C143: Standard Test Method for Slump of Hydraulic Cement Concrete
         11) ASTM C173: Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
         12) ASTM C231: Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
         13) ASTM C260: Air Entrainment Admixtures for Concrete
         14) ASTM C309: Standard Specifications for Liquid Membrane Forming Compound for Curing Concrete
         15) ASTM C494: Chemical Admixtures for Concrete
c. Pre-Cast:
   1) ASTM C478: Standard Specification for Precast Reinforced Concrete Manholes Sections
   3) ASTM C858: Standard Specification for Underground Precast Concrete Utility Structures
   4) ASTM C891: Standard Practice for Installation of Underground Precast Concrete Utility Structures
   5) ASTM C1037: Standard Practice for Inspection of Underground Precast Concrete Utility Structures
   6) ASTM D1751: Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)

2. Trenching and Backfill:
   a. ASTM D1557: Test Method for Laboratory Compaction Characteristics Using Modified Effort

1.4 SUBMITTALS

A. Comply with the Submittal portion of Division 27 Specification Section Basic Communications Requirements. Provide submittal information for the following:
   1. Product Data
   2. Shop Drawings:
      a. Raceway/pathway routing: Provide a raceway/pathway routing plan if such plan has not been shown on the Drawings, or if the Contractor is proposing a deviation from that shown.
         1) If a routing plan is not required, submit written documentation stating that the routing will be provided as shown on the Drawings, that the Contractor has reviewed the routing shown on the Drawings with the other applicable trades and that all have agreed that it does not create conflicts between the trades, and the routing meets applicable codes, regulations and standards.
         2) If a routing plan is required, submit complete site plans or detail drawings showing the proposed routing and raceway sizes and locations in a manner equal to that of the Drawings. Ensure that any routing changes are coordinated with comparable changes to the communications cable routing. Specifically note each location where the proposed routing is different from the Drawings. Where deviations are proposed, submit written documentation detailing the reason for each. Each deviation must be approved in writing by the Engineer prior to proceeding with installation.

1.5 DEFINITIONS

A. Aggregate: The mineral materials such as sand or stone used in making concrete

B. Backfill: Earth material used specifically for filling and grading excavations back to a finished state. Backfill is placed on top of the bedding surrounding encased ductbanks and direct-buried conduits.

C. Base: Earth material used specifically to level and grade an excavation’s subgrade for the subsequent placement of encased ductbanks, direct-buried conduit, and UCVs. Base material is placed on top of the subgrade and beneath the bedding surrounding encased ductbanks, conduits, or UCVs.

D. Bedding: Earth material used specifically for filling excavations. Bedding is placed around encased ductbank, conduits, or UCVs. Bedding is placed on top of the base and beneath the backfill.
E. Fill: The collective term for base, bedding, and backfill.
F. Handhole: A small UCV in which it is expected that a person cannot enter to perform work. Handholes are primarily used for the placement of cable, but are also occasionally used for splicing or for equipment.
G. Maintenance hole: A large UCV in which it is expected that a person can enter to perform work. Maintenance holes may be used for splicing and outside-rated telecommunications equipment.
H. Pullhole: A small UCV in which it is expected that a person cannot enter to perform work. Pullholes are used for the placement of cable only; they are not used for splicing or for equipment.
I. Underground Cable Vault (UCV): Underground vaults (maintenance holes, handholes, or pullholes) which are used for the routing of communications cable.
J. Vault: See Underground Cable Vault (UCV).

PART 2 - MATERIALS

2.1 GENERAL
A. Materials shall consist of fill, topsoil, concrete formwork, concrete, raceway, UCVs, and other incidentals and accessories as required.
B. Comply fully with Governing Requirements as listed in Division 27 Specification Section Basic Communications Requirements.
C. Comply fully with UCB Standards Sections as listed in Division 27 Specification Section Electrical – General Requirements.

2.2 BASE, BEDDING AND BACKFILL
A. Comply fully with UCB Standards Section Trenching, Backfilling, Compacting.
B. Use of onsite soils for base and bedding is not acceptable. Compacted onsite materials are acceptable for backfill.
C. Base: Base material shall have size and shape characteristics that will allow it to compact readily and shall conform to the following gradation requirements.
   1. For Trenches (provide sand):
      | Sieve Size | Percent Passing |
      |------------|----------------|
      | U.S. No. 10 | 35 - 100       |
      | U.S. No. 20 | 20 - 80        |
      | U.S. No. 40 | 10 – 55        |
      | U.S. No. 100 | 0 – 10         |
      | U.S. No. 200 | 0 - 3          |
D. Bedding: Same as Base - For Trenches, above.
E. Backfill:
   1. For Trenches
      | Sieve Size     | Percent Passing |
      |---------------|----------------|
      | ½-inch Square | 100            |
      | ¼-inch Square | 65 – 100       |
      | U.S. No. 10   | 40 – 100       |
      | U.S. No. 50   | 3 – 50         |
      | U.S. No. 100  | 0 – 4          |
      | U.S. No. 200  | 0 - 3          |
2.3 CAST-IN-PLACE CONCRETE

A. Formwork:
   1. Forms: Forms shall be metal or plywood in good condition. The Contractor will be allowed to use the most advantageous panel sizes and panel joint locations. Neat patches and minor surface imperfections will be permitted. Surfaces formed shall be true planes within ¼-inch in 10-feet.
   2. Form Release Agent: Where metal or plywood forms are used the forms shall be coated with a form release agent prior to placement of concrete. Except for gypsum board, faces and edges of forms shall be coated with Burke Form Coating (or equal) applied at a rate of 500 to 550 square feet per unit.
   3. Curved Surfaces: Only curved forms shall be used for constructing curved structures and surfaces.

B. Reinforcement:
   1. Reinforcing Steel: Reinforcing Steel shall conform to ASTM A615, Grade 40. Steel shall be uncoated, free from rust, dirt, and loose scale.
   2. Tie Wire: Tie wire shall be 18 gauge 40 or heavier black annealed wire.
   3. Embedded Anchor Bolts: Embedded anchor bolts shall be mild galvanized steel, cold bent.

C. Concrete:
   1. Cement: Different types of cement, including the same type of cement provided by more than one manufacturer, are not acceptable: Cement shall conform to:
      a. ASTM C150-7, type 1.
      b. Minimum compressive strength shall be 3,000 psi at 28 days per ASTM C39.
      c. Maximum slump shall be 4 inches per ASTM C-143.
   2. Aggregate: Aggregate shall conform to:
      a. Course: ASTM C33-71 with a maximum size of 1-¼ inches.
   3. Water: Water shall be fresh, clean, potable and not detrimental to concrete.
   4. Admixtures:
      a. Air Entrainment: Conform to ASTM C260 and ASTM C173 or C231 with 5 percent to 7 percent air entrainment.
      b. Other: Other admixtures shall not be used without prior approval.
   5. Curing Compound: Curing compound shall conform to ASTM C309 and shall be free from petroleum resins or waxes. Sealer-hardener formulated for sealing, surface hardening, and curing concrete shall be utilized. Curing method and rate of application shall be according to manufacturers recommendations.

2.4 DUCTS AND DUCTBANKS

A. Ducts: Provide in locations as shown on the drawings. Refer to Part - 3, Execution for details on when to use each type. All conduit, fittings, and adhesives shall be provided by the same manufacturer.
   1. Types:
      a. RNC – Rigid Non-Metallic Conduit (PVC):
         1) Schedule 40 or 80:
            a) RNC, unless otherwise noted, shall be NEMA TC 2 or TC 6 schedule 40 or 80 (see Part - 3, Execution for details on when to use each type) rigid polyvinyl chloride (PVC) approved for direct burial without concrete encasement. RNC shall be UL listed.
            b) Fittings shall be NEMA TC 3 or TC 9, matched to conduit and material.
               i. Four-inch 45 degree fiberglass bend: FRE Composite Ins., 30-4032 Elbow IPS
               ii. Four-inch 90 degree fiberglass bend: FRE Composite Ins., 30-4030 Elbow IPS
2) EB-20:
   a) EB-20 conduit shall be ETL listed, tested to UL651A, and meet the requirements of NEMA TC-6 and ASTM F-512.
   b. RGS – Rigid Galvanized Steel Conduit:
      1) RGS shall be rigid steel conduit hot-dipped galvanized inside and out with threaded ends meeting ANSI C80.1.
      2) Couplings: Unsplit, NPT threaded with galvanizing equal to and compatible with conduit. Running thread or set screw threaded fittings (except for three piece and watertight split couplings) are not acceptable.
      3) Nipples: Factory made through eight-inches with no running threads.
   c. PSC – PVC Coated Rigid Steel Conduit:
      1) PSC shall be NEMA RN 1 rigid steel conduit coated with rigid polyvinyl chloride (PVC) on exterior.
      2) Fittings shall be NEMA RN 1.

2. Fittings:
   a. Conduit Joint Couplings:
      1) PVC non-metallic fittings shall be installed with solvent applied couplings.
      2) An approved transition coupling shall be used to connect metal to plastic (PVC) conduits.
      3) Couplings may be threaded and/or glued to provide watertight seal at conduit junctions.
   b. Bends/Sweeps:
      1) Bends/sweeps shall be factory manufactured.
      2) Bends shall consist of a single arc of not less than a 15 foot radius. Where this is not possible due to existing site conditions, a bend radius shall not be less than 10 times the internal diameter of the conduit.
      3) The use of 90 degree elbows, LB’s, condulets, or the use of a UCV in place of a bend/sweep is not acceptable.
   c. End Caps (Plugs): Provide pre-manufactured water-tight end caps (General Machine Products 6668R16) for all ducts. Tape is not an acceptable end cap or cover.
   d. Conduit Caulking Compound: Compounds for sealing conduit ducts shall have putty-like consistency workable with the hands at temperatures as low as 35 degrees Fahrenheit, shall not slump at a temperature of 300 degrees Fahrenheit, and shall not harden materially when exposed to the air. Compounds shall readily caulk or adhere to clean surfaces of plastic conduit, metallic conduit, or conduit coatings; concrete, masonry; any cable sheaths, jackets, covers, or insulation material, and the common materials. Compounds shall form a seal without dissolving, noticeable changing characteristics, or removing any of the ingredients. Compounds shall have no injurious effect on the hands of workers or upon materials.
   e. End Bells: Provide end bells (Carlon E297N) for terminating conduit in UCVs. Do not provide for conduit ends terminating in UCVs which are equipped with TERM-A-DUCT.

3. Pull Ropes: Provide ¼ inch polypropylene pull ropes indicating length measurement in each duct. Pull rope strength shall be a minimum of 130 pounds.

4. Core Drill Seals: Core drill seals shall be Link-Seal waterproof assembly or preapproved equal (PSI/Thunderline/Link-Seal).

B. Ductbanks:
   1. Unless otherwise noted on the Drawings, ductbanks shall consist of concrete encased RNC (see CAST-IN-PLACE CONCRETE, above).
2. Warning Tape: Provide Manufacturer’s standard, permanent, continuous-printed polyethylene film tape with metallic core, intended for direct burial service; not less than 3-inches wide and 4 mils thick. Provide orange tape with black printing reading, “CAUTION TELEPHONE/DATA CABLE BELOW”, or similar.
3. Tracer wire: Provide a continuous (non-spliced) #6 tracer wire along length of ductbank. Tracer box shall be NEMA-1 4-inch x 4-inch weatherproof box.

PART 3 - EXECUTION

3.1 GENERAL

A. Work shall comply with the Governing Requirements as defined in Division 27 Specification Section Basic Communications Requirements.
   1. Governing Requirements of particular relevance to this Section include, but are not limited to:
      a. TIA/EIA - 758: Customer-owned Outside Plant Telecommunications Cabling Standard
      b. TIA/EIA - 568: Commercial Building Telecommunications Cabling Standard
      c. TIA/EIA - 569: Commercial Building Standard for Telecommunication Pathways and Spaces
      d. TIA/EIA - 606: The Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
      e. TIA/EIA - 607: Commercial Building Grounding and Bonding Requirements for Telecommunications
      f. BICSI: Customer Owned Outside Plant Design Manual
      g. BICSI: Telecommunications Distribution Methods Manual
      h. BICSI: BICSI Telecommunications Cabling Installation Manual
      i. Washington State DOC: Telecommunications Infrastructure Standards
   2. The Contractor shall pay particular attention to and comply with the following Owner Governing Requirements:
      a. UCB Telecommunications Standards:
         (http://www.colorado.edu/facilitiesmanagement/pdc/construction/standards/documents/Division27CommunicationsSpecifications.pdf)

3.2 EXCAVATING, TRENCHING AND FILL

A. Inspection
   1. Examine areas and conditions under which the new exterior telecommunications pathways are to be installed. Provide written notification to Owner and Engineer of any conditions detrimental to proper completion of work.
   2. Verify field measurements and pathway routing conditions are as shown on Drawings. Provide written notification to Owner and Engineer of any conditions deviating from Drawings.
   3. Beginning of telecommunications pathway installation indicated Contractor’s acceptance of existing conditions.
   4. Post and comply with CONSTRUCTION INSPECTION REPORT – VOICE AND DATA COMMUNICATIONS attached to UCB Standards Section 270100 – Life-Cycle Activities for Communications Work.

B. Excavation:
   1. Perform trenching, backfilling and compaction as specified in Drawings and UCB Standards Section 02220 and 02221.
   2. All utilities shall be located by Contractor and exposed, if necessary, prior to construction.
   3. Excavations shall not be performed where the outside temperature is less than 35 degrees Fahrenheit or when there is standing water or snow on the subgrade.
4. Excavations requiring crossing of concrete or asphalt shall be performed only after the surface material has been saw cut and removed. Concrete shall be removed in complete sections from control joint to control joint regardless of the width of the excavation. Concrete and asphalt shall be replaced to match existing depth, strength, color, and type of material.

5. Adjacent structures which may be compromised or damaged by excavation work shall be underpinned as evaluated and recommended by a registered structural engineer employed by the Contractor prior to proceeding with the work.

6. The Contractor shall maintain adequate separation between the excavation and adjacent underground utilities. The excavation shall be located such that ductbank and UCVs, when installed, shall have a minimum separation of twelve inches of well tamped dirt between the ductbank and UCV and the nearest underground utility. For gas lines a minimum separation of eighteen inches is required. For water a minimum separation of thirty-six inches is required.

7. Communications conduit/duct runs under slab shall not share a trench with conduit/duct runs from other trades.

8. Excavations shall not be left unprotected at the end of the work shift. Excavations shall be covered with steel sheets and barricaded prior to leaving the job site, in accordance with all applicable rules, regulations, building codes, and ordinances.

9. The Contractor shall not allow water to accumulate in excavations. The Contractor shall install, operate and maintain all pump or dewatering equipment necessary to meet this requirement.

10. Depth of excavation
   a. For UCVs: Depth shall allow for the overall assembled height of the vault plus the added height of risers, covers and bedding material consisting of a minimum six to twelve inches of base. Width of excavation for UCVs shall provide for a minimum of six (6)-inches clearance around each side of the UCV.
   b. For trenches: Depth shall be sufficient to cover a minimum of twenty-four inches (36 inches wherever possible) over the conduit or ductbank formation. Width of excavation for trenches shall be a minimum of six inches to each side of the ductbank formation. Depth of excavation for trenches shall allow for the proper alignment of ducts into UCVs.

11. Soft spots in the subgrade shall be over-excavated, filled, and compacted.

12. Excavation for trenching shall run true and as straight as practicable. Trenches shall be clear of stones and soft spots.

13. Trench grade shall be sloped to fall 3-inches per 100 feet in general and ¼ inch per foot where possible.
   a. Slope shall fall toward lower UCVs or from high points toward both UCVs.
   b. Slope shall always fall away from building entrances.

C. Fill:
1. Prior to the placement of fill, all groundwater and surface water shall be drained or pumped from the recipient area.
2. Frozen fill shall not be placed.
3. Base:
   a. The subgrade bed to receive fill shall be scarified and moisture conditioned prior to placing materials.
   b. Base material shall be moisture conditioned to within three percent of optimum moisture content and shall be placed in loose, horizontal layers.
   c. The subgrade bed shall be leveled using sand for trenches and gravel for UCVs as necessary to form an even base.
4. Bedding:
   a. For concrete encased ductbank:
      1) Bedding lifts/layers shall not exceed 4-inches before compaction.
   b. For Direct-buried Ductbank:
      1) Lifts/layers shall not exceed 1 to 2 inches before compaction until the top of the ductbank is reached and shall not exceed 4 inches thereafter. Bedding shall be placed simultaneously on both sides of ductbank for the full width of the trench. The materials shall be carefully worked above, to each side, and below the ducts with a tool capable of preventing the formation of void spaces and without damaging the structure or waterproofing of the ducts.

5. Backfill:
   a. Backfill lifts/layers shall not exceed 6 inches before compaction.

6. Compaction: Compaction shall be performed using a vibratory plate or roller or other mechanical device. Compaction through jetting or ponding is not acceptable. Compact per APWA Standard Specification Paragraph 7-10.3 (11).
   a. Bedding: Material shall be compacted to a dense state equaling at least 95 percent of the maximum dry density per ASTM D1557.
   b. Backfill: Material shall be compacted to within two (2)-feet of the finished surface with a minimum relative compaction of 90 percent of the maximum dry density per ASTM D1557. Material within two (2)-feet of the finished surface shall be compacted with a minimum relative compaction of 95 percent of the maximum dry density per ASTM D1557.

D. Waste Disposal: The Contractor shall remove all excavation materials and other construction debris from the site in a timely manner. Materials shall be disposed of legally.

3.3 CAST-IN-PLACE CONCRETE

A. Concrete shall be constructed in accordance with the applicable portions of the specifications, standards, codes and regulations (latest editions and amendments) listed in Section 1, References.

B. The Contractor shall submit a copy of the delivery receipt for each concrete delivery which shall include date, strength ordered, and location used.

C. Formwork:
   1. Construction:
      a. Forms: Forms shall be cleaned and free of debris prior to pouring concrete. Braces shall be unyielding and tight to prevent leakage. Maintain formwork construction tolerances complying with ACI 347. Formwork shall be readily removable without impact, shock, or damage to concrete surfaces and adjacent materials.
      b. Reinforcement: Reinforcement shall be constructed in accordance with ACI SP-6. Weld reinforcement in accordance with ANSI/AWS D1.4 or ANSI/AWS D12.1. Accurately position, support, and secure reinforcement against displacement. Support reinforcement by metal/plastic chairs, runners, bolsters, spacers, hangers, or other incidental materials as required.
   2. Removal: Remove forms after concrete has cured (see Curing below) for 7 days or after concrete has attained a compressive strength of 2000 psi.

D. Concrete:
   1. Transport: Contractor shall comply with ACI 304. Concrete shall be transported from the mixer to the construction location via methods preventing separation of materials.
2. Application:
   a. Prior to placement, inspect and complete formwork construction, reinforcement, and items to be embedded or cast-in.
   b. Deposit concrete in forms in layers not deeper than 24 inches and in a manner to avoid inclined construction joints. Where placement consists of several layers, place each layer on the preceding layer while the preceding layer is still plastic. Cold joints are not acceptable.
   c. Concrete shall be deposited in a plastic condition and shall be uniformly worked around reinforcements.
   d. Concrete shall be consolidate by internal machine vibration (stinger) during pouring.
   e. Once concrete work has commenced, work shall be continuous until the work segment or section has been completed.
   f. Cold Weather: Concrete shall be protected from damage caused by frost, freezing, or low temperatures in compliance with ACI 306R. When temperature is below 40 degrees F, water and aggregates shall be heated before mixing to obtain a concrete mixture of not less than 50 degrees F and not more than 80 degrees F.
   g. Hot Weather: Concrete shall be protected from damage caused by hot weather in compliance with ACI 305R. When temperature is above 90 degrees F water shall be chilled before mixing to obtain a concrete mixture of not more than 90 degrees F. Cover reinforcing steel with water-soaked burlap if it becomes too hot immediately before placement of concrete. Temperature of steel shall not exceed the ambient air temperature.

3. Curing:
   a. Concrete shall be protected from premature drying, rain, excessive temperatures, and mechanical injury during the curing period.
   b. Concrete shall be cured for 7 days in accordance with ACI 301 and shall be kept continuously moist during this time. Concrete temperature shall be strictly maintained between 50 degrees and 90 degrees F during the curing period.

4. Finish:
   a. Surfaces shall be consolidated, leveled and screened for evenness and uniformity. All excess concrete shall be removed. Low spots shall be filled.

5. Ductbanks:
   a. Concrete shall not be poured against trench walls. Concrete shall be consolidated during placement by an internal concrete vibrator.
   b. Secure duct spacers/supports and reinforcing to prevent movement during concrete placement.

3.4 DUCTS AND DUCTBANK

A. Ducts:
1. The type of duct to use shall be dictated by the application:
   a. Outdoor underground – direct buried: Provide RNC Schedule 80 (Type II) or PSC.
      1) Transition to PSC at stub up locations and at entrances to buildings (a minimum 10 feet from building foundation) or other locations where the raceway changes from encased in concrete to direct buried or exposed conditions.
      2) Transition to PSC or RGC for short radius bends (i.e. bends with less than 15-foot radii sweeps).
      1) Transition to PSC at stub up locations and at entrances to buildings (a minimum 10 feet from building foundation) or other locations where the raceway changes from encased in concrete to direct buried or exposed conditions.
   c. Exposed or within 5 feet of steam lines or Utilidor trenches: Provide RGC.
2. Fittings:
   a. Duct ends shall be cut square and reamed to remove burrs and sharp ends. Duct shall extend the maximum distance into all fittings, couplings, and connectors. All fittings shall be tightened securely and sealed watertight (see below).
   b. Bends/Sweeps:
      1) Bends shall consist of a single arc of not less than a 15 foot radius. Where this is not possible, a bend radius shall not be less than 10 times the internal diameter of the conduit. Short radius bends (45 and 90 degrees) are not permissible.
      2) An individual bend shall not exceed 90 degrees.
      3) A duct section may have no more than the equivalent of two 90 degree bends (a total of 180 degrees) between pull points. The 180 degree maximum shall include kicks and offsets. Where it is not possible to construct a section of duct within the 180 degree bend maximum, intermediary UCVs must be installed.
      4) Two 90 degree bends separated by less than 10 feet is not permissible.
      5) Bends forducts within a common ductbank shall be parallel, measured from the same center-point.
      6) Where factory manufactured bends cannot be obtained due to a unique bend radius, bends shall be formed only with factory recommended equipment and shall be manufactured in such a way as to ensure that the internal diameter of the duct is not changed.
   c. End Caps (Plugs): End caps shall be placed on all duct ends throughout construction in order to prevent the intrusion of water or debris. End caps shall be installed on all duct that is not directly being worked on during the work day and on all ducts at night. End caps shall be left in place upon final completion of the work.
   d. End Bells: For UCVs which are not equipped with TERM-A-DUCT, install protective end bells on ducts flush with UCV wall.

3. Sealing:
   a. Seal openings around conduits that pass through inside building wall coredrills with UL listed foamed silicon elastomer compound.
   b. Seal openings around conduits that pass through outside building walls with a complete Link-Seal assembly or preapproved equal for a waterproof seal. Slope conduit away from building.
   c. Seal openings around conduits that pass through UCV (vault) walls with foundation foam on the interior of the core and silicon sealer on the inside and outside of the core for a waterproof seal.
   d. Duct connections shall be made waterproof and rustproof by application of a watertight, conductive thread compound (for RGC and PSC) or by solvent-type cement (for RNC). Duct terminations in UCVs shall be sealed and grouted (to ensure that all voids in the joints are filled). Duct terminations in buildings shall be sealed/watertight until used for cable.

4. Test Mandrels: Each duct, once installed, shall be cleaned of debris with a wire brush or swab and shall be proven out with a minimum 16 inch long test mandrel which is ¼ inch smaller than the inside diameter of the duct. Test mandrel shall be pulled after backfilling but prior to the replacement of landscaping. The Contractor shall repair any duct that does not prove out at no cost to the Owner.
   a. Duct shall be cleaned a minimum of two times in the same direction and swabbed with clean rags until the rag comes out of the conduit clean and dry. Swab away from buildings for duct sections connected to buildings.

5. Duct Entrances:
   a. UCV’s:
      1) Duct entrances at opposite ends of a UCV shall be at the same level and in the same position with respect to the side walls. The Contractor shall ensure that each duct leaving a UCV in any position shall enter the next UCV in the same relative position.
2) UCVs shall not be drilled or penetrated without written Owner permission.

b. Buildings: Ducts shall terminate 4-inches above the finished floor.

6. Length: Unless otherwise shown on the Drawings, the maximum length of a duct run shall not exceed 500 feet between UCVs or pulling points. Install additional UCVs as required to maintain spacing.

7. Pull Ropes: Install in each duct immediately after the duct has been cleaned and mandreled. Leave a minimum of 10 feet looped and tied off at each end of the duct. Pull rope shall be ¼-inch nylon rope.

8. Protection: Insure that after installation all duct coatings and finishes are without damage. Repair as follows:
   a. PVC Coated Rigid Steel Conduit: Patch all nicks and scrapes in PVC coating after installing conduits.
   b. Rigid Galvanized Steel Conduit: Repair damage to galvanized finishes with zinc-rich paint as recommended by the manufacturer.
   c. Rigid Non-metallic Conduit: Repair damage with matching touchup coating recommended by the manufacturer.

B. Ductbanks:
   1. Encased in Concrete:
      a. See CAST-IN-PLACE CONCRETE, above.
   2. Duct Spacers/Supports: Supports shall be spaced on eight (8) foot centers if encased in concrete and five foot centers otherwise. Spacers shall be interlocked horizontally only. Spacers encased in concrete shall be staggered at least six inches vertically.
   3. Warning Tape: Install metallic warning tape six inches below grade.
   4. Grounding/Bonding: Install ground wire along length of ductbank. Bond to grounding electrodes of UCV’s and to building service grounds.
   5. Ductbank slope shall be such that ducts will drain away from building entrances (i.e. slope away from buildings).

END OF SECTION
PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes general requirements for the Maintenance and Hand Holes (Underground Cable Vaults) for the Communications System. General requirements are covered in Division 27 Specification Section Electrical – General Requirements.

1.2 RELATED SECTIONS

A. The requirements of this Section are additional to, different from, or otherwise supplement the applicable requirements of Division 26. The applicable requirements of Division 26 shall serve as the basis for the requirements of this Section, and are incorporated by reference into this Section.

B. The requirements of this Section are additional to, different from, or otherwise supplement the applicable requirements of Specification Section Electrical – Underground Ducts and Raceways. The applicable requirements of Specification Section Electrical – Underground Ducts and Raceways shall serve as the basis for the requirements of this Section, and are incorporated by reference into this Section.

1.3 REFERENCES

A. In addition to the Governing Requirements, the applicable portion of the following shall be incorporated by reference into this Section:
   1. Concrete:
      a. Pre-Cast:
         2) ASTM C858: Standard Specification for Underground Precast Concrete Utility Structures
         3) ASTM C891: Standard Practice for Installation of Underground Precast Concrete Utility Structures
         4) ASTM C1037: Standard Practice for Inspection of Underground Precast Concrete Utility Structures
         5) ASTM D1751: Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
      2. Trenching and Backfill:
         a. ASTM D1557: Test Method for Laboratory Compaction Characteristics Using Modified Effort

1.4 SUBMITTALS

A. Comply with the Submittal portion of Division 27 Specification Section Basic Communications Requirements. Provide submittal information for the following:
   1. Product Data
   2. Shop Drawings:
      a. UCV location: Provide a UCV location plan if such plan has not been shown on the Drawings, or if the Contractor is proposing a deviation from that shown.
1.5 DEFINITIONS

A. Aggregate: The mineral materials such as sand or stone used in making concrete

B. Backfill: Earth material used specifically for filling and grading excavations back to a finished state. Backfill is placed on top of the bedding surrounding encased ductbanks and direct-buried conduits.

C. Base: Earth material used specifically to level and grade an excavation’s subgrade for the subsequent placement of encased ductbanks, direct-buried conduit, and UCVs. Base material is placed on top of the subgrade and beneath the bedding surrounding encased ductbanks, conduits, or UCVs.

D. Bedding: Earth material used specifically for filling excavations. Bedding is placed around encased ductbank, conduits, or UCVs. Bedding is placed on top of the base and beneath the backfill.

E. Fill: The collective term for base, bedding, and backfill.

F. Handhole: A small UCV in which it is expected that a person cannot enter to perform work. Handholes are primarily used for the placement of cable, but are also occasionally used for splicing or for equipment.

G. Maintenance hole: A large UCV in which it is expected that a person can enter to perform work. Maintenance holes may be used for splicing and outside-rated telecommunications equipment.

H. Pullbox: A small UCV in which it is expected that a person cannot enter to perform work. Pullboxes are used for the placement of cable only; they are not used for splicing or for equipment.

I. Underground Cable Vault (UCV): Underground vaults (maintenance holes, handholes, or pullbox(es) which are used for the routing of communications cable.

J. Vault: See Underground Cable Vault (UCV).

PART 2 - MATERIALS

2.1 GENERAL

A. Materials shall consist of fill, topsoil, UCVs, and other incidentals and accessories as required.

B. Comply fully with Governing Requirements as listed in Division 27 Specification Section Basic Communications Requirements.

C. Comply fully with UCB Standards Sections as listed in Division 27 Specification Section Electrical – General Requirements.

2.2 BASE, BEDDING AND BACKFILL

A. Comply fully with UCB Standards Section Trenching, Backfilling, Compacting.

B. Use of on-site soils for base, bedding, and backfill is not acceptable.
C. Base: Base material shall have size and shape characteristics that will allow it to compact readily and shall conform to the following gradation requirements.

1. For UCVs (provide gravel):

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 inch Square</td>
<td>100</td>
</tr>
<tr>
<td>¼ inch Square</td>
<td>25 – 80</td>
</tr>
<tr>
<td>U.S. No. 200</td>
<td>15.0 max</td>
</tr>
<tr>
<td>Sand Equivalent</td>
<td>30 min</td>
</tr>
</tbody>
</table>

D. Backfill:

1. For UCVs - Same as Base - For UCVs, above.

2.3 UNDERGROUND CABLE VAULTS (UCVS)

1. Manufacturer: UCVs shall be precast in an established precast yard. Precast components shall conform to the requirements of ASTM C858 and other ASTM standards and specifications as listed in References, above. Precast UCVs shall be free from damaged joint surfaces, cracks, or other damage that would permit infiltration. Precast concrete structures may be repaired; repairs shall be performed only by the manufacturer in such a manner as to ensure that the repaired structure conforms to the requirements of this Specification and ASSTM C858. UCVs and incidental and miscellaneous equipment (such as cable racking brackets and supports) shall be supplied by a single manufacturer.

B. UCVs:

1. Maintenance holes: Maintenance holes shall be provided in the locations and sizes (minimum inside dimensions) shown on the Drawings. Maintenance holes shall utilize circular covers and shall be provided with circular maintenance hole entrance riser sections which shall be used to maintain the maintenance hole cover level with the existing ground line or final grade. Maintenance holes shall be complete with permanently installed ladders and 12 inch diameter closed sumps.

   a. Sizes and Types:
      1) Maintenance Hole (Manhole): 4’x6’x7’ two-piece precast concrete communications vault equipped with 30-inch frame and cover, 12-inch and 6-inch grade rings as required. Hardware shall include ladder, pulling-in irons, cable racks, “S” rack supports, steps, plastic conduit end bells, and lead tag for identification.
      b. Covers and Frames: Covers shall be circular cast iron, shall be embossed in the lid casting with minimum 2 inch high letters stating “COMMUNICATIONS”, and shall conform to AASHTO H20 loading. Covers and frames shall be complete with lock-down bolts. Cover frames shall be cast ductile iron, conforming to the same AASHTO requirements as the covers. All covers and frames shall be of uniform quality, free from blowholes, porosity, shrinkage, distortion, cracks and other defects. Repair of defects is not acceptable. All mating surfaces shall be machine finished to ensure a non-rocking fit. Covers and frames shall be:
         1) CASTING 30 inches by 6 inches
      c. Racking and Hardware:
         1) Cable Rack with Support Hardware as required:
            a) 18 Hole: Condux 08380200 or Chance C203-1126
            b) Other sizes as required: Condux or Chance
         2) Cable Rack Steps/Hooks:
            a) 4-inch: Condux 08380600 or Chance C203-1131
            b) Other sizes as required: Condux or Chance
         3) “S” Rack Supports: Condux or Chance
         4) Step Lock Wedge: Panduit CHW-C20
5) Racking and hardware shall be galvanized. Provide three cable racks per longitudinal side (six racks total) per maintenance hole. Provide eight 7-½ inch cable support arms per maintenance hole. Provide all incidental hardware for mounting racks and cable support arms.

d. Risers: Riser sections shall be a minimum 4 inch high and a maximum 12 inch high, sized for the maintenance hole entrance, and provided in sufficient quantities to maintain the maintenance hole cover level with the existing ground line or final grade. Risers shall be:

1) 37-inch diameter grade ring

2. Handholes: Handholes shall be provided in the locations and sizes shown on the Drawings.
   a. Sizes and Types:
      1) 2’x3’x18” deep communications vault constructed of precast concrete with a minimum thickness of 1.5-inches including base. Cover shall be either precast concrete, steel, or cast-iron and shall be permanently labeled “T” for telecommunications.

C. Grounding: UCVs (with the exception of small pullboxes) shall be complete with a minimum of one ¾ inch by 10 foot copperclad steel ground rods, and one #6/0 pigtail for connection to interior ground conductors.

**PART 3 - EXECUTION**

3.1 GENERAL

A. Work shall comply with the Governing Requirements as defined in Division 27 Specification Section Basic Communications Requirements.

1. Governing Requirements of particular relevance to this Section include, but are not limited to:

   a. TIA/EIA - 758: Customer-owned Outside Plant Telecommunications Cabling Standard
   b. TIA/EIA - 568: Commercial Building Telecommunications Cabling Standard
   c. TIA/EIA - 569: Commercial Building Standard for Telecommunication Pathways and Spaces
   d. TIA/EIA - 606: The Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
   e. TIA/EIA - 607: Commercial Building Grounding and Bonding Requirements for Telecommunications
   f. BICSI: Customer Owned Outside Plant Design Manual
   g. BICSI: Telecommunications Distribution Methods Manual
   h. BICSI: BICSI Telecommunications Cabling Installation Manual

2. The Contractor shall pay particular attention to and comply with the following Owner Governing Requirements:

   a. **UCB Telecommunications Standards:**
      (http://www.colorado.edu/facilitiesmanagement/pdc/construction/standards/documents/Division27CommunicationsSpecifications.pdf)

3.2 EXCAVATING, TRENCHING AND FILL

A. Excavation:

1. Perform all trenching, backfilling and compaction for new underground conduit system placement as shown on Drawings and as specified in UCB Standards Section 02220 and 02221.

2. All utilities shall be located by Contractor and exposed, if necessary, prior to construction.

3. Excavations shall not be performed where the outside temperature is less than 35 degrees Fahrenheit or when there is standing water or snow on the subgrade.
4. Excavations requiring crossing of concrete or asphalt shall be performed only after the surface material has been saw cut and removed. Concrete shall be removed in complete sections from control joint to control joint regardless of the width of the excavation. Concrete and asphalt shall be replaced to match existing depth, strength, color, and type of material.

5. Adjacent structures which may be compromised or damaged by excavation work shall be underpinned as evaluated and recommended by a registered structural engineer employed by the contractor prior to proceeding with the work.

6. The Contractor shall maintain adequate separation between the excavation and adjacent underground utilities. The excavation shall be located such that ductbank and UCVs, when installed, shall have a minimum separation of twelve inches of well tamped dirt between the ductbank and UCV and the nearest underground utility. For gas lines a minimum separation of eighteen inches is required. For water a minimum separation of thirty-six inches is required.

7. Communications conduit/duct runs under slab shall not share a trench with conduit/duct runs from other trades.

8. Excavations shall not be left unprotected at the end of the work shift. Excavations shall be covered with steel sheets and barricaded prior to leaving the job site, in accordance with all applicable rules, regulations, building codes, and ordinances.

9. The Contractor shall not allow water to accumulate in excavations. The Contractor shall install, operate and maintain all pump or dewatering equipment necessary to meet this requirement.

10. Depth of excavation
   a. For UCVs: Depth shall allow for the overall assembled height of the vault plus the added height of risers, covers and bedding material consisting of a minimum six to twelve inches of base. Width of excavation for UCVs shall provide for a minimum of six inches clearance around each side of the UCV.
   b. For trenches: Depth shall be sufficient to cover a minimum of 24 inches (36 inches wherever possible) over the conduit or ductbank formation. Width of excavation for trenches shall be a minimum of six inches to each side of the ductbank formation. Depth of excavation for trenches shall allow for the proper alignment of ducts into UCVs.

11. Soft spots in the subgrade shall be over-excavated, filled, and compacted.

12. Excavation for trenching shall run true and as straight as practicable. Trenches shall be clear of stones and soft spots.

13. Trench grade shall be sloped to fall 3 inches per 100-feet in general and ¼ inch per foot where possible.
   a. Slope shall fall toward lower UCVs or from high points toward both UCVs.
   b. Slope shall always fall away from building entrances.

B. Fill:
1. Prior to the placement of fill, all groundwater and surface water shall be drained or pumped from the recipient area.
2. Frozen fill shall not be placed.
3. Base:
   a. The subgrade bed to receive fill shall be scarified and moisture conditioned prior to placing materials.
   b. Base material shall be moisture conditioned to within three percent of optimum moisture content and shall be placed in loose, horizontal layers.
   c. The subgrade bed shall be leveled using sand for trenches and gravel for UCVs as necessary to form an even base.
4. Backfill:
   a. Backfill lifts/layers shall not exceed 6 inches before compaction.
5. Compaction: Compaction shall be performed using a vibratory plate or roller or other mechanical device. Compaction through jetting or ponding is not acceptable. Compact per APWA Standard Specification Paragraph 7-10.3 (11).
   a. Bedding: Material shall be compacted to a dense state equaling at least 95 percent of the maximum dry density per ASTM D1557.
   b. Backfill: Material shall be compacted to within 2 feet of the finished surface with a minimum relative compaction of 90 percent of the maximum dry density per ASTM D1557. Material within 2 feet of the finished surface shall be compacted with a minimum relative compaction of 95 percent of the maximum dry density per ASTM D1557.
   c. Waste Disposal: The Contractor shall remove all excavation materials and other construction debris from the site in a timely manner. Materials shall be disposed of legally.

3.3 UNDERGROUND CABLE VAULTS (UCVS)

A. UCVs shall be installed strictly according to the manufacturer’s recommendations.

B. Setting and Placement: Excavations shall be free of water and shall have bedding material properly installed prior to setting the UCV. Section seal surfaces must be clean and free from dirt or other material.
   1. UCVs shall be set in place by lowering each section of the UCV into the excavation, ensuring that the UCV section is set level, plumb, and firmly positioned, and ensuring that the section gasket/seal is properly installed and watertight prior to setting the next section.
   2. The UCVs shall be carefully set in order to ensure that the maintenance hole rim/lid elevation shall be:
      a. Flush: For existing concrete or asphalt in paved and improved areas
      b. 2 inches above grade: For landscaped or unimproved areas

C. Knockouts: Knockouts shall be removed by striking the knockout with a single moderately heavy blow with a hammer or similar tool.

D. Duct Entrances: Duct entrances at opposite ends of a UCV shall be at the same level and in the same position with respect to the side walls. The Contractor shall ensure that each duct leaving a UCV in any position shall enter the next UCV in the same relative position.

E. Grouting: Grout shall be applied in a manner to insure filling of all voids in the joints being sealed. Grouting shall be applied to conduit entrances, risers, and covers in addition to any other voids.

F. Racking and Hardware: Install racking and hardware and incidental materials.

G. Grounding/Bonding: Bond all metallic hardware in the vault to the pre-cast bonding tabs. Bond the bonding tabs to the ground rod.

H. Cleaning: The UCV shall be completely cleaned and dried after all construction activity is complete and prior to releasing the UCV to the Owner for the Owner’s use.
<table>
<thead>
<tr>
<th>ID</th>
<th>DESCRIPTION</th>
<th>Manufacturer/Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>UG140</td>
<td>Maintenance Hole/Vault</td>
<td>Amcor Precast 467-CV</td>
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<tr>
<td>UG300</td>
<td>Handhole</td>
<td>See Special Rqmt Communications Products VAULT22436181A</td>
</tr>
</tbody>
</table>

END OF SECTION
SECTION 27 10 00
COMMUNICATIONS - GENERAL REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes general cabling requirements for the Communications Cabling System.

1.2 RELATED SECTIONS
A. Division 27 Specification Section Common Work - Sleeves, Penetrations and Firestopping. Provide sleeves, penetrations, and firestopping as required to support the work of this Section.
B. Division 27 Specification Section Common Work – Hangers and Supports. Provide hangers and supports as required to support the work of this Section.

1.3 SUBMITTALS
A. Provide the following per the criteria set forth in Submittals in Division 27 Specification Section Basic Communications Requirements:
   1. Product Data
   2. Shop Drawings:
      a. Cable Routing: Provide a cable routing plan if communications cable routing has not been shown on the Drawings, or if the Contractor is proposing a deviation from that shown.
         1) If a routing plan is not required, submit written documentation stating that the routing will be provided as shown on the Drawings, that the Contractor has reviewed the routing shown on the Drawings with the other applicable trades and that all have agreed that it does not create conflicts between the trades, and the routing meets applicable codes, regulations and standards.
         2) If a routing plan is required, submit complete floor plans or detail drawings showing the proposed routing, raceway sizes and locations, and cabling in a manner equal to that of the Drawings. Ensure that any routing changes are coordinated with comparable changes to the raceway routing. Specifically note each location where the proposed routing is different from the Drawings. Where deviations are proposed, submit written documentation detailing the reason for each. Each deviation must be approved in writing by the Engineer prior to proceeding with installation.
      b. Termination Block Wall Field Terminations and Elevations: Provide termination block wall field termination diagrams and elevation drawings where such diagrams and elevations have not been shown on the Drawings, or if the Contractor is proposing a deviation from that shown.
         1) Where changes to the wall field termination diagrams and elevation drawings are proposed, submit wall field termination diagrams and elevation drawings in a manner equal to that of the Drawings. Specifically note areas where deviations are proposed, and submit written documentation detailing the reason for each. Each deviation must be approved in writing by the Engineer prior to proceeding with installation.
   3. Samples:
      a. Provide one full size installation sample/mock-up for each of the following components. All samples are to be fully labeled per the Specifications and shall be complete with all associated components necessary to make a complete mock-up. Samples will be used to set the standard for the quality of work required of the Contractor throughout the project. Installation work not meeting the sampled standard will be rejected and shall be replaced by the Contractor at no additional cost to the Owner.
1) Horizontal cable(s): Provide a mock-up of each type of outlet configuration shown on the Drawings. The samples shall be complete with the outlet box, 36 inch length(s) of horizontal cable(s), strain relief, faceplate, connector(s), and other incidental components as required for a complete outlet. Label each outlet per the Specifications. The cable shall show all cable markings.

2) Copper Backbone Cable: Provide a 24 inch length of each type of copper backbone cable. The outer jacket shall be stripped back 6 inches from one end to allow the individual pairs to be inspected. Label each cable per the Specifications. The cable shall show all cable markings.

3) Fiber Backbone Cable: Provide a 24 inch length of each type of fiber backbone cable. The outer jacket shall be stripped back 12 inches from one end to allow the individual fiber sub-cable groups to be inspected for all cables. Label each cable per the Specifications. The cable shall show all cable markings.

4) Coaxial Backbone Cable: Provide a 24 inch length of each type of coaxial backbone cable. Label per Specifications. The cable shall show all cable markings.

4. Other:
   a. Owner Specific: Submit other information as required by Owner Specific Governing Requirements in Specification Section Basic Communications Requirements.

PART 2 - MATERIALS

2.1 GENERAL

A. Manufacturer: Structured cabling system components shall be sourced by a single Manufacturer or formally partnered Manufacturers (collectively referred to as the “Manufacturer”). Products shall not be intermixed between different manufacturers unless the Manufacturer of the chosen communications cabling system has listed (in writing) another manufacturer’s component as an “approved alternative product” (or equivalent wording) and will warrant the “approved alternative product” as part of the Manufacturer’s extended Warranty, or if the product has been specifically called out as a special requirement in the Specifications. Additionally, for a given Manufacturer, all products shall be part of a single product line and the product line shall be specifically engineered “end-to-end” (e.g. the system and all of its components shall have been engineered to function together as a single, continuous transmission path). The structured cabling system shall be:
   1. Hubbell – Mission Critical

B. Plenum Rating:
   1. Cable shall be plenum (CMP, OFNP) rated if installed in a plenum environment, non-plenum rated (CM/CMR, OFNR) otherwise, or per local Governing Requirements or code as required.
   2. The Contractor is solely responsible for determining the plenum rating of the environment in which cable is to be installed, and for doing so prior to procurement and installation of the cable. Non-plenum cable installed in an environment determined to be plenum rated shall be removed and replaced by the Contractor at no additional cost to the Owner.
   3. All cabling shall bear plenum or non-plenum markings for the environment in which they are installed.

C. Color: All cables of the same type (i.e. Copper Backbone, Copper Horizontal, Fiber Horizontal, Coaxial CATV Trunk, 62.5µm MM, 50µm MM, SM, etc.) shall be of the same color. Multiple colors of the same cable type are not acceptable.

D. Part Numbers: Refer to the equipment schedule at the end of this Section for specific part numbers. If no part number is provided, then any part meeting the requirements specified is acceptable.
2.2 PERFORMANCE

A. Protocols/Services:
   1. At a minimum, the communications cabling system shall support data network
      protocols/services at rates up to 1 Gbps for transmission on copper, and 10 Gbps for
      transmission on fiber. It shall support Ethernet, ATM and other network protocols. The
      communications cabling system shall additionally support RS-232 and other dedicated point-
      to-point protocols.
   2. The communications cabling system shall support PBX telephone services. It shall support
      analog, digital, and ISDN services, and shall be compatible with direct trunk lines (POTS).

B. Category Rating: Copper components (cable, connectors, etc.) shall meet or exceed the TIA/EIA
   transmission requirements for the Category for which they are rated.
   1. Horizontal Cable shall be:
      a. Category 6:
         1) Wireless Access Point
      b. Category 5e (350Mhz):
         1) Access Control System
         2) Other cabling, including voice and other data circuits
   2. Backbone Cable shall be rated Category 3 or higher.

C. Performance Rating: All components (copper and fiber) shall meet or exceed TIA/EIA
   transmission requirements for their component type.

D. Fiber Performance:
   1. OSP Backbone Cable:
      a. 62.5/125 µm Multimode: Provide extended/high grade cable with a maximum
         attenuation of 3.5 dB/km at 850 nm and 1.0 dB/km at 1300 nm. The minimum cable
         bandwidth shall be 200 MHz-km at 850 nm and 500 MHz-km at 1300 nm. Color shall be
         orange.
      b. Singlemode: Provide cable with a maximum attenuation of 1.0 dB/km @ 1310 nm and
         1.0 dB/km at 1550 nm. Color shall be yellow.
   2. ISP Backbone Cable:
      a. For Fire Alarm only: 62.5/125 µm Multimode. Provide extended/high grade cable with a
         maximum attenuation of 3.5 dB/km at 850 nm and 1.0 dB/km at 1300 nm. The minimum
         cable bandwidth shall be 200 MHz-km at 850 nm and 500 MHz-km at 1300 nm. Color
         shall be orange.
      b. For all other ISP cabling: 50/125 µm Laser Optimized Multimode. Provide cable with a
         maximum attenuation of 3.0 dB/km at 850 nm and 1.0 dB/km at 1300 nm. The minimum
         cable bandwidth shall be 2000 MHz-km at 850 nm and 500 MHz-km at 1300 nm. Color
         shall be aqua.
      c. Singlemode: Provide cable with a maximum attenuation of 1.0 dB/km @ 1310 nm and
         1.0 dB/km at 1550 nm. Color shall be yellow.

PART 3 - EXECUTION

3.1 GENERAL

A. Work shall comply with the Governing Requirements as defined in Division 27 Specification
   Section Basic Communications Requirements. Governing Requirements of particular relevance
   to this Section include, but are not limited to:
   1. TIA/EIA - 568: Commercial Building Telecommunications Cabling Standard
   2. TIA/EIA 569: Commercial Building Standard for Telecommunication Pathways and Spaces
   3. ANSI/EIA 310-D: Cabinets, Racks, Panels and Associated Equipment
4. TIA/EIA 606: The Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
5. ANSI J-STD-607: Commercial Building Grounding and Bonding Requirements for Telecommunications
6. TIA/EIA -758: Customer-owned Outside Plant Telecommunications Cabling Standard
7. ANSI/TIA 942: Telecommunications Infrastructure Standard for Data Centers
8. IEEE 802.3 (series): Local Area Network Ethernet Standards

B. Owner required Governing Requirements of particular relevance to this Section include, but are not limited to:
1. University of Colorado at Boulder:
   a. UCB Division 27 Telecommunications Standards
   b. UCB Construction Drawings As-built Requirements
   c. UCB Cable Footage and Count Information
   d. UCB Construction Inspection Report
   e. UCB Approved Rack Details
   f. UCB ITS Telecom CAD Standards Guidelines
   g. UCB Labeling and Testing Document
   h. UCB Jack Numbering Document (T-5)
   i. UCB Wireless Ceiling and Wall Security Box Instructions
   j. UCB Typical Telecommunications Conduit Layouts Drawing

3.2 GENERAL INSTALLATION
A. Maintain separation from other conductors (power, fire alarm, etc.) per NEC requirements and TIA/EIA standards.
B. The bending radius and pull strength requirements of all cable as detailed in the Governing Requirements and Manufacturers recommendations shall be strictly observed during handling and installation.
C. Pull cables simultaneously where more than one cable is being installed in the same raceway.
D. Use pulling compound or lubricant where necessary. Use compounds that will not damage conductor or insulation.
E. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips that will not damage cable or raceway.
F. Cable jackets shall not be twisted during installation. Cables showing evidence of twisting shall be replaced at no additional cost to the Owner, regardless of the outcome of cable testing.
G. Cable shall be installed in a continuous (non-spliced) manner unless otherwise indicated on the Drawings. Where splicing may be required in areas not shown on the Drawings due to Cable Spool length limitations or otherwise, the Contractor shall obtain the approval of the Engineer prior to procurement and installation.
H. Provide strain relief to ensure durable connections at all cable termination locations.
I. Pathway/Raceway Validation: The Contractor is responsible for validating pathway/raceway sizing against the amount of cable it is to support for compliance with NEC and TIA/EIA 569 cable capacity standards. The Contractor shall notify the Engineer of all raceways the Contractor determines to be insufficient in size and shall await the Engineer’s direction prior to procurement and installation.

J. Copper Cables:
   1. Backbone Cable: All pairs shall be terminated. Unless otherwise noted on the Drawings, the installation of un-terminated cable pairs is not acceptable. For shielded cable, bond both ends of the metallic shield (or metallic strength member) to the nearest TGB.
   2. Horizontal Cable: Thoroughly clean and remove foreign material from outlet boxes prior to installation of cable.

K. Coaxial Cable:
   1. Extreme care shall be taken not to kink coaxial cables during installation. Cable ends shall be protected prior to termination.

L. Fiber Cables:
   1. Cables shall be tested on reel prior to installation. Cable which does not pass shall not be installed and shall be replaced at no additional cost to the Owner. “Repairing” cables which do not pass is not acceptable.
   2. All fiber strands shall be terminated. Unless otherwise noted on the Drawings, the installation of un-terminated (i.e. “dark fiber”) is not acceptable.
   3. Fiber splices shall be fusion. Mechanical splices are not acceptable. Each fusion splice shall be protected in a splice tray or similar protective device that is designed to mount within the enclosure. Bare/stripped optical fiber strands shall be protected with a buffer tube, heat shrink or silicon adhesive to prevent exposure to moisture.

M. Provide Sleeves and Penetrations as necessary where cable must pass through building barriers such as walls, floors or foundations. Firestop all through and membrane penetrations of fire-rated barriers. Sleeves, Penetrations and Firestopping shall be per the requirements of Division 27 Specification Section Common Work - Sleeves Penetrations and Firestopping.

3.3 CABLE INSTALLED IN RACEWAY

A. In Conduit or Ducts:
   1. Fill ratios shall not exceed NEC requirements.
   2. Cable shall not be pulled into conduit/ducts until the conduit/duct ends have been prepared for cable installation (i.e. ducts cleaned and swabbed, reamed to eliminate sharp edges, bushings installed (insulated throat for metallic conduits, PVC for PVC conduits), etc.). Cables pulled into conduit/ducts prior to conduit/duct end preparation shall be removed and replaced (after the conduit/duct ends are prepared) at no additional cost to the Owner.
   3. Backbone (riser) cables shall not share conduits/ducts with horizontal cables.
   4. Reinstate pull-wires in conduits and ducts after use to facilitate future addition of cables.

B. In Cable Tray:
   1. Cable shall not be attached to the cable tray (i.e. cable shall be left “loose”).
   2. Cable shall be laid in tray in such a way as to present a neat and professional appearance. However, cable shall not be combed (for performance reasons).
   3. For cable tray serving both backbone (riser) and horizontal cabling, install cable in cable tray in such a manner that backbone cabling does not overlap with horizontal cabling – reserve approximately 25 percent of the space in the tray for backbone cabling and the remaining 75 percent for horizontal cabling.
   4. Where cables in cable trays are required to maintain specific distances between each other they shall be firmly secured to maintain this distance at fire rated penetrations.
3.4 CABLE NOT INSTALLED IN RACEWAY (E.G. “EXPOSED”):

A. Cables shall be installed in raceway unless specifically specified by Engineer or Owner.

B. Cables shall be strapped, fastened or tie-wrapped for support. Staples are not acceptable.
   1. Straps, fasteners, and tie-wraps shall not be over-tightened. Cables showing evidence of over-tightening shall be replaced at no additional cost to the Owner, regardless of the outcome of cable testing.
   2. Straps, fasteners, and tie-wraps installed in plenum spaces shall be plenum rated.
   3. Cables shall be loosely grouped by application (horizontal or backbone) and by cable type (Cat 3, Cat 5E, Cat 5, Cat 6, MM Fiber, SM Fiber, etc.). Cable applications and types shall not be intermixed within a grouping.

C. Cables in suspended cable runs shall be supported at varying intervals. Cable spans shall be limited to 5 feet or less, and the length of spans shall vary along the cable path (i.e. a given span should not be exactly the same length as the span preceding or following it – “exact” spans can degrade cable performance).

D. Cable installed on exposed surfaces or structural members shall be installed parallel and perpendicular to the surfaces. Surface contours shall be followed wherever possible. Cables shall be attached to surfaces at intervals not to exceed 3 feet, and the length of spans shall vary along the cable path (i.e. a given span should not be exactly the same length as the span preceding or following it – “exact” spans can degrade cable performance).

E. Attaching cables to pipes, electrical conduit, mechanical items, existing cables, or the ceiling support system (grids, hanger wires, etc. – with the exception of ceiling support anchors) is not acceptable.

F. Where expressly allowed, cables exiting floor or wall penetrations and running exposed into furniture or casework shall be bundled and wrapped in spiral wrap or split-loom tubing for protection.

G. The quantity of cables installed in j-hooks, straps, and other similar fasteners shall not exceed manufacturer maximum loads for the fastener. Provide additional fasteners as required to meet load and future capacity requirements.

H. Route cable to comply with the Governing Requirements standards and rules for avoiding potential EMI sources of interference and as follows:
   1. Provide clearances of:
      a. 18 inches from light fixtures
      b. 12 inches from electrical power distribution (including conduits and cables)
      c. 4 feet from motors and transformers
   2. Cable pathway shall cross perpendicular to potential EMI sources of interference.

3.5 CABLE IN COMMUNICATIONS ROOMS AND SPACES

A. Cable on backboards:
   1. Lay and dress all cables to allow other cables to enter raceway (conduit or otherwise) without difficulty at a later time by maintaining a working distance from these openings.
   2. Cable shall be routed as close as possible to the ceiling, floor, sides, or corners to insure that adequate wall or backboard space is available for current and future equipment and for cable terminations.
   3. Lay cables via the shortest route directly to the nearest edge of the backboard from mounted equipment or blocks. Secure all similarly routed and similar cables together and attach to D-rings vertically or horizontally, then route over a path that will offer minimum obstruction to future installations of equipment, backboards or other cables.
   4. Copper riser cables shall be routed so as to feed into termination blocks from the bottom.
B. Cable Bundles:
1. Cables shall be bundled by application (horizontal or backbone) and by cable type (Cat 3, Cat 5E, Cat 5, Cat 6, MM Fiber, SM Fiber, etc.). Cable applications and types shall not be intermixed within a bundle.
2. Cable bundles shall be combed to present a neat and professional appearance. For performance reasons, combing shall occur from the cable end to a maximum of 35 feet back (or per the Manufacturer’s recommendations, whichever is more stringent). For the portion of a cable bundle within the communications room exceeding this requirement (if any), the exterior cables in the cable bundle shall be combed straight. Interior cables shall not be combed (i.e. they shall be left “mixed”).

C. Cable in ladder rack on walls: Place larger cable bundles against wall, smaller cable bundles to the inside.

D. Cable straps: Install cable straps to secure cable bundles to cable runway and other supporting equipment. The use of plastic tie wraps for this purpose is not acceptable. Comply with Division 27 Specification Section Communications - Equipment Room Fittings.

3.6 CABLE SLACK

A. Cable slack in communications rooms and spaces: Store slack by circling cable around communications room in the Cable Runway as shown on the Drawings.
1. Provide Slack length as follows:
   a. Inside Plant Cable: 10 feet minimum for all cable types (horizontal and backbone)
   b. Outside Plant Cable:
      1) Copper Backbone Cable: 10 feet minimum
      2) Coaxial CATV: 10 feet minimum
      3) Fiber Backbone Cable: 50 feet minimum
2. Where Cable Runway does not exist or where slack storage is not called out on the Drawings, slack shall be stored as follows:
   a. Copper Cable:
      1) Horizontal: Slack shall be stored in a serpentine loop manner, not in the form of a circular “loop” (for performance reasons).
      2) Backbone: Slack shall be stored in circular “loops”.
   b. Coaxial CATV: Slack shall be stored in circular “loops”.
   c. Fiber Cable: Slack shall be stored in circular “loops”.

B. Cable slack at the work area outlet: Provide 1 foot of slack. Slack shall be stored in a serpentine loop manner, not in the form of a circular “loop” (for performance reasons).

C. Cable slack at Wireless Access Point enclosures (ceiling and wall mounted): Twenty feet of slack shall be stored in a serpentine manner and stored within the Wireless Access enclosure.

D. In cases of extreme congestion, notify the Engineer and await the Engineer’s direction prior to installation.

3.7 OUTSIDE PLANT INSTALLATION

A. Duct/Direct-Buried:
1. Mandrels: Prior to installation of cable, each duct shall be cleaned of debris with a wire brush or swab and shall be proven out with a test mandrel of sufficient length to verify the TIA/EIA minimum bend radii requirements and with a diameter which is ⅛ inch smaller than the inside diameter of the duct. Duct shall be cleaned a minimum of two times in the same direction and swabbed with clean rags until the rag comes out of the conduit clean and dry. Swab away from buildings for duct sections connected to buildings.
2. Cables shall be installed in strict compliance with the Governing Requirements and manufacturers recommendations. Bending radius, pulling tension, other mechanical stresses, and pulling speed as detailed in the manufactures recommendations and TIA/EIA standards shall be strictly observed. Pulling tension shall be monitored for all runs of 300 feet or longer. Acceptable monitoring devices are:
a. Winch with a calibrated maximum tension
b. Breakaway link (swivel)
c. In-line tensiometer

3. Cable reels shall be set up on the same sides of UCV’s as conduit sections in which cables are to be placed. Reels should be leveled and aligned with conduit sections to prevent twisting of cables during installation into conduits. Cables shall be pulled into conduits from tops of reels in long smooth bends. Cables shall not be pulled into conduits from bottoms of reels. A cable feeder guide (shoe) of suitable dimensions shall be used between the cable reel and the face of the duct to protect the cable and guide it into the duct. As the cables are paid off the reel, they shall be carefully inspected for sheath defects. If defects are found during the pulling operation or if the cable on the reel binds, twists, or does not pay off freely, the pulling operation shall be stopped immediately and the Owner’s representative notified.

4. Cables of 1-¼ inches or larger diameter shall be equipped with factory installed pulling eyes. Pulling grips are to be used for cables smaller than 1-¼ inches in diameter. Grips with rings to prevent the grips from slipping shall not be beaten into the cable sheath. A ball-bearing based swivel shall be used between the pulling-eyes or grips and the pulling strand.

5. Once pulling begins, and tension is applied to the cable, the pull shall be continued at a steady rate. If it is necessary to stop the pull at any point, the pull should be stopped but the tension should not be released unless it is necessary to do so.

6. Cables shall not be placed in ducts other than those specifically indicated on the Drawings. For new ductbank, cables shall be installed in the lowest available conduit in a duct bank, working up as additional cables are installed or as detailed on the Drawings. Coordinate duct utilization with Owner prior to cable procurement.

7. Where cables are pulled through UCV’s, duct selections shall be the same at both ends of UCV’s unless specifically noted on the Drawings. Changes in duct selections, especially in elevations, shall be avoided to ensure that no damage occurs to the cable sheaths and that pulling tensions are kept as low as possible.

8. A sufficient length of cable shall be left in each UCV to properly rack the cable, and to provide for splicing operations which may be required outside of the UCV. In the event that the UCV contains cabling routed directly to a building entrance, a sufficient length of cable entering the building shall be left in the UCV to allow for re-termination in the building without the use of a splice in the event of future cable damage between the UCV and the building. Cables in UCV’s shall be racked as soon as practicable and in no case shall racking occur greater than one week after cable installation. Cables in UCV’s shall be routed to avoid blocking duct access.

9. Cables shall be fed into ducts from the end of the duct that creates the least sidewall pressure on a bend during installation (i.e. cable should be fed from the end closest to the bend).

10. Use pulling compound or lubricant where necessary. Lubricants shall be specifically produced for the installation of telecommunications cable, shall be compatible with the cable jacket material and shall be used in accordance with manufacturer’s recommendations. Soap-based lubricants shall not be used. Where cable is pulled through a UCV, the cable shall be re-lubricated prior to feeding into the next duct. Immediately after cables have been installed, exposed cables in UCV’s and at termination points shall be cleaned of lubricants using dry rags.

11. Cable ends shall be sealed and protected with end caps immediately after installation and until terminated in a termination enclosure, in order to prevent moisture entry into the core of filled cables and to prevent damage during installation.
12. Installation of outdoor rated cable at building entrances shall comply with the National Electric Code (NEC) Article 800 “50-ft rule” (i.e. total exposed outdoor rated cable length within a building shall not exceed 50 feet). Where this is not possible due to existing field conditions, the Contractor shall notify the Engineer and await direction prior to cable installation.

13. Building Entrances: All in-use and spare conduits entering the building from the outside plant shall be sealed to prevent intrusion of water, gases, and rodents.

END OF SECTION
SECTION 27 11 00
COMMUNICATIONS - EQUIPMENT ROOM FITTINGS

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes requirements for providing equipment and materials for TIA/EIA compliant communications equipment rooms and spaces including, but not limited to, telecommunications rooms, equipment rooms, entrance facilities, server rooms, etc. General requirements for equipment room fittings are covered in Division 27 Specification Section Communications – General Requirements.

1.2 RELATED SECTIONS
A. The requirements of Division 27 Specification Section Electrical - General Requirements shall serve as the basis for the requirements of this Section, and are incorporated by reference into this Section.

1.3 SUBMITTALS
A. Provide the following per the criteria set forth in Submittals in Division 27 Specification Section Basic Communications Requirements:
   1. Product Data
   2. Shop Drawings:
      a. Provide the following for each Communication Room, if: a) Communications Rooms are not shown on the Drawings; b) Communication Rooms are only shown as “Typical” on the Drawings; c) or the Contractor is proposing a deviation to the Drawings:
         1) Wall elevations (all four walls)
         2) Plan view/layout
      b. Provide the following only if elevations have not been shown on the Drawings, or if the Contractor is proposing a deviation.
         1) Wall Field Cable/Jumper Management Elevations, including designation of cable and pair terminations within the wall field.

PART 2 - MATERIALS

2.1 GENERAL
A. Manufacturer: Racks, frames, cabinets, enclosures, rack cable distribution hardware, cable runway (ladder rack), and other distribution and incidental components shall be manufactured by a single Manufacturer unless specifically stated otherwise. The manufacturer shall be:
   1. Chatsworth Products, Inc. (CPI)

B. Part Numbers: Refer to the equipment schedule at the end of this Section for specific part numbers. If no part number is provided, then any part meeting the requirements specified is acceptable.

C. Color: Unless otherwise indicated, the color of all cable runway, equipment racks, frame, and cabinets, distribution hardware, and other distribution and incidental equipment shall be:
   1. Cable runway and associated materials: Gray
   2. Equipment racks: clear chem/brushed aluminum
   3. Vertical management sections: black
   4. Server Cabinets: black
D. Seismic Bracing: Equipment shall be seismically braced as required by code. Bracing shall be rigid – non-rigid bracing (chains, cables, etc.) is not acceptable, unless otherwise specified by code. Seismic bracing hardware shall be provided by the manufacturer, or shall be approved or recommended by the manufacturer. Where no manufacturer hardware, approval, or recommendation is available, the seismic assembly shall be approved by a licensed structural engineer.

2.2 CABLE RUNWAY (LADDER RACK)

A. Cable runway system shall be complete with all fittings, miscellaneous hardware, and other incidental hardware required for a complete and fully fitted system, including but not limited to splice kits, support hangers, rods, and brackets, center supports, j-bolts, foot kits, vertical wall brackets, wall angles, support hardware, grounding hardware, and protective end caps for exposed cable runway ends. Provide as shown on the Drawings or as defined below:

1. Straight Section (Standard Rung Spacing): Cable runway shall be available in 6 inch, 12 inch, 18 inch, 24 inch widths and shall have runway cross-members (rungs) spaced at 12 inch intervals, and shall be painted gray.

2. Straight Section (Alternate Rung Spacing): Alternate Rung Spacing Cable runway shall be available in 6 inch, 12 inch, 18 inch, 24 inch widths and shall have runway cross-members (rungs) spaced at alternating 12.5 inch and 13.81 inch intervals. Alternate rung spacing runway is used to simplify vertical alignment of cable runway installed across the top of equipment racks with standard 6 inch vertical cable management sections.

3. Corner Bracket: Corner brackets shall be used to create radii for T-junctions and corners.

4. Triangular Support Brackets: Triangular Support Brackets shall be provided for all locations where cable runway is to be mounted on a wall. Triangular Support Brackets shall be sized and provided in quantities according to the width and fully loaded capacity of the cable runway to be supported.

5. Radius Drop: Radius Drops shall be provided for all locations where cable is to drop from one section of cable runway to another lower section of cable runway, or is to drop from cable runway to equipment racks, frames, or cabinets. Radius Drops shall be either Cross Member or Stringer type according to their application, and sized in widths according required to support their application.

6. Elevation Kits: Elevation kits shall be provided for all equipment racks and frames where cable runway is routed across the tops of equipment racks and frames and is not mounted at the same height as the tops of the equipment racks or frames. Elevation Kit height shall be sized per the distance between the top of the rack or frame and the cable runway.

7. Rack-to-Runway Mounting Plate: Mounting Plates shall be provided for all equipment racks and frames where cable runway is mounted directly to the top of equipment racks or frame. Mounting Plate shall be 3 inches wide and sized according to the width of the cable runway to be attached.

8. Wall Angle Support: Wall Angle Supports shall be provided for all locations where cable runway stops at walls or where Triangular Support Brackets cannot be utilized due to field conditions. Wall angles shall be sized and provided in quantities according to the fully loaded capacity of the cable runway to be supported.

2.3 EQUIPMENT RACKS, EQUIPMENT FRAMES, SERVER FRAMES AND CABINETS

A. Equipment shall be free standing and shall be complete and fully fitted with all miscellaneous and incidental hardware required, including but not limited to hardware required for assembly, securing to floor, grounding, and seismic bracing (as required by local codes). Height shall be as shown on the Drawings. Provide as shown on the Drawings and as follows:

1. Equipment Racks: Equipment racks shall be 19 inch wide with universal alternating hole patterns on both sides of the posts, 3 inch channels, 2 posts, top angles, self-supporting bases, and assembly hardware.
2. Server Cabinet:
   a. Thermal Containment System: Hot Aisle Containment System coordinated with server cabinets. Furnish and install baying kits, ceiling assemblies, divided cable troughs for network cables – segregating UTP patch cords from fiber-optic patch cords, door and frame assemblies, and locks, for a complete and functional hot aisle containment system.
   b. APC AR3150: Cabinet shall be 42U, 1991 mm high x 750 mm wide x 1070 mm deep, and shall be equipped with overhead cable troughs and partitions for cable management, and Power Distribution Units.
      1) Baying hardware
      2) Keyed-alike doors and side panels
      3) Perforated front door
      4) Side panels
      5) Top panels
      6) Preinstalled casters and leveling feet
      7) Mounting hardware, with cage nuts for mounting equipment
      8) Data Cable troughs and Partitions
      9) Vertical Cable organizers, full height, left and right sides
      10) Tool-less 1 RMU blanking panels for 75% of cabinet space
      11) Air recirculation prevention kits to support hot aisle containment
      12) Metered, vertical, Zero U cabinet PDU - left and right sides

2.4 RACK-MOUNT ACCESSORIES
A. Provide as shown on the Drawings and as follows:
   1. Horizontal Power Strip: Provide as shown on Drawings. Power strips shall be rack-mountable, 1.75 inches (1U) high by 19 inches wide, shall be rated at 15 amps, and shall have a minimum of 10 outlets, and shall be equipped with a power cord of sufficient length to route to the power receptacle serving the equipment rack/frame.
   2. Vertical Power Strip (PDU):
      a. L21-20P Vertical power strips shall be metered, zero U 1778 mm high 5.7kW 208V, with NEMA L21-20P input connection with 10-foot cord length and 36 IEC 320 C13 and 6 IEC 320 C19 output connections. Vertical power strip shall include all rack mounting hardware. APC AP7894.
      b. CS8365 Vertical power strips shall be metered, zero U 1778 mm high 12.5kW 208V, with NEMA L21-20P input connection with 10-foot cord length and 30 IEC 320 C13 and 6 IEC 320 C19 output connections. Vertical power strip shall include all rack mounting hardware. APC AP7898.
   3. Filler panel: Filler panel shall be an airflow management blanking panel to prevent air recirculation by occupying unused rack space. Filler panels shall be complete with all mounting hardware. Coordinate final quantities and locations with Owner.
   4. Air Recirculation Prevention Kit: Air recirculation prevention kit shall prevent the recirculation of warm air exhaust inside the enclosure by closing gaps between vertical mounting flanges and the side panels of the enclosure.
   5. Coordinate with Owner’s final equipment location.
   6. Dust covers: Dust covers shall cover the space between base angles of two-post racks.

2.5 CABLE MANAGEMENT
A. Provide as shown on the Drawings and as follows:
   1. Vertical Cable Management Sections: Vertical cable management sections shall be single or double sided, and shall be provided in widths and heights as shown on the Drawings.
   2. Patch Cord Organizer (Interbay Cable Organizer): Provide as shown on Drawings. Unless shown otherwise on Drawings, interbay cable organizers shall be mounted at the top of equipment racks, frames and enclosures to route patch cables and jumpers. Interbay cable organizers shall be 19 inches wide.
3. Cable Management Trough: Match server cabinet width, 183 mm high and 323 mm deep, with partitions to organize fiber optic and copper cables separately.
4. Distribution Rings: Provide for all locations where cable or jumpers will be routed on backboards and similar surfaces. Size shall be appropriate to the quantity of cable to be supported, and shall be a minimum of 2 inches in diameter. Rings shall be manufactured by CPI, or equal. Type of ring shall be as follows:
   a. C-Rings (“open” rings): Provide for those cables or jumpers which will likely be subjected to frequent moves, adds, or changes.
   b. D-Rings (“closed” rings): Provide for those cables or jumpers not likely to be subjected to frequent moves, adds, or changes.

2.6 BACKBOARDS
A. Provide backboards as shown on the Drawings. Backboards shall be ¾ inch exterior grade Douglas Fir A-C plywood, void free, 2440-mm (8 feet) high unless otherwise noted, capable of supporting attached equipment. Width shall be as required to fully cover walls. Backboards shall be as follows:
   1. Backboards shall be fire-resistant or non-combustible, painted with two coats of light colored fire retardant paint.

2.7 GROUNDING AND BONDING
A. Telecommunications Equipment Bonding Conductor (TEBC): Provide insulated green or insulated green with yellow strip - 6 AWG copper conductor as short and direct as possible, not to exceed 100 feet in length to bond all non-current-carrying metal telecommunications equipment and materials to the nearest TGB per Division 27 Specification Section Electrical – Grounding and Bonding.

PART 3 - EXECUTION

3.1 GENERAL
A. Work shall comply with the Governing Requirements as defined in Division 27 Specification Section Basic Communications Requirements. Governing Requirements of particular relevance to this Section include, but are not limited to:
   1. TIA/EIA 569: Commercial Building Standard for Telecommunication Pathways and Spaces
   2. ANSI/EIA 310-D: Cabinets, Racks, Panels and Associated Equipment
   3. TIA/EIA 606-A: The Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
   4. ANSI J-STD-607: Commercial Building Grounding and Bonding Requirements for Telecommunications
   5. TIA/EIA 607: Commercial Building Grounding and Bonding Requirements for Telecommunications

B. Seismic Bracing: Install seismic bracing as required by code.

3.2 CABLE RUNWAY (LADDER RACK)
A. Cable Runway shall be installed per manufacturer’s instructions and shall be installed with flat (rung) side up/out. Install with ends cut square, and reamed to remove burrs and sharp edges. Cap cut ends with manufacturer’s recommended caps. Affix cable radius drop outs wherever cable will “waterfall” from one runway elevation to another, or from runway to equipment.
3.3 EQUIPMENT RACKS, EQUIPMENT FRAMES, SERVER FRAMES AND CABINETS
A. Install equipment complete with all required incidental hardware and materials.
B. Bond all non-current carrying metal telecommunications equipment and materials to the nearest TGB. Ensure that grounding is provided across all cable runway splices and between cable runway and all equipment racks/frames, etc.
C. Free Standing Equipment Racks and Frames:
   1. Secure cable runway to equipment racks/frames and to walls as shown on the Drawings. Secure racks/frames to floor per manufacturer’s instructions.
   a. Rack-to-Runway Mounting Plate: Secure to cable runway and equipment racks and frames. Mounting plates shall be mounted either parallel or perpendicular, depending upon the orientation of the ladder rack
   2. When installing Vertical Cable Management Sections between equipment racks/frames, install management such that the management trough is as far back as possible between the racks/frames, to ensure a clean/even front side of the rack/frame.
   3. When installing multiple adjacent equipment racks/frames, bolt adjacent racks (and management, where shown) together per manufacturer’s instructions to ensure a stable, rigid frame.

3.4 CABLE MANAGEMENT
A. Distribution rings: Mount at minimum 1 foot intervals.

3.5 BACKBOARDS
A. Mount backboards on walls in locations shown on the Drawings with base of backboard at +12 inches AFF (unless otherwise noted on the Drawings), with the “A” side exposed. Securely fasten plywood to wall-framing members to ensure that it can support attached equipment.

3.6 GROUNDING AND BONDING
A. Telecommunications Equipment Bonding Conductor (TEBC): Bond all non-current carrying metal telecommunications equipment and materials to the nearest TGB with a bonding conductor.
   1. Route along the shortest and straightest path possible with minimal bends.
   2. Bends shall be sweeping.
   3. Bonding conductors shall be continuous (without splices) and shall be insulated from their support.
   4. Ensure that bonding breaks through paint to bare metallic surface of all painted metallic hardware.
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SECTION 27 11 19
COMMUNICATIONS - TERMINATION EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes requirements for equipment to terminate communications cable in communications equipment rooms and spaces. General requirements for termination equipment are covered in Division 27 Specification Section Communications - General Requirements.

1.2 RELATED SECTIONS
A. The requirements of Division 27 Specification Section Communications - General Requirements shall serve as the basis for the requirements of this Section, and are incorporated by reference into this Section.

1.3 SUBMITTALS
A. Comply with the Submittal portion of Division 27 Specification Section Basic Communications Requirements. Provide submittal information for the following:
   1. Product Data

PART 2 - MATERIALS

2.1 GENERAL
A. Manufacturer: Unless otherwise indicated, equipment in this Section shall be of the same Manufacturer as that specified under Division 27 Specification Section Communications - General Requirements.

B. Part Numbers: Refer to the equipment schedule at the end of this Section for specific part numbers. If no part number is provided, then any part meeting the requirements specified is acceptable.

2.2 PATCH PANELS
A. Provide patch panels in sizes and quantities as required to support all cables to be terminated. The sizes and quantities shown on the Drawings are for representative purposes only, and may or may not be the final sizes and quantities required. The Contractor shall provide sizes and quantities as required to support all cables to be terminated.
   1. Copper: Copper patch panels shall be rack mountable and sized as shown on the Drawings. Patch panel connectors shall be 8-position/8-conductor, insulation displacement (IDC), non-keyed, and shall accept modular 8-position/8-conductor plugs. Patch panels shall support a universal (T568A and T568B) wiring pattern, shall meet or exceed the transmission requirements for connecting hardware as specified in the Division 27 Specification Section Communications - General Requirements for the Category for which they are rated, shall be equipped with pre-manufactured cable management support bar/strain relief for supporting cables behind the patch panel, and shall be complete with all incidental materials necessary for mounting and installation of the panel and support of the cables which shall be connected to it. Patch panels shall be available in 24-port and 48-port styles.
      a. Horizontal Copper Patch Panels: Provide for terminating copper horizontal cables. Patch panel Category rating shall be the same as that specified under Division 27 Specification Section Communications - General Requirements.
b. Voice-Grade Copper Backbone Patch Panels: Provide for termination of high pair count voice-grade Category 3 rated copper backbone cables. Patch Panel shall be Category 3 rated or higher.

c. Utility Tie Cable Patch Panels: Provide as shown on Drawings. Provide for termination of voice-grade Category 3 rated copper utility tie cables in TRs. Patch Panel shall be Category 3 rated or higher.

d. Data-Grade Copper Backbone Patch Panels: Provide for termination of data-grade 4-pair cable used for connectivity between communications rooms. Patch panel Category rating shall be the same as that specified under Division 27 Specification Section Communications - General Requirements.

2. Fiber: Fiber patch panels shall be dual purpose, capable of both termination/connectorization and splicing (fusion or mechanical) of fiber in the same enclosure, shall support both regular and high-density connectors, and shall be sized as shown on the Drawings. Fiber patch panels shall consist of enclosures pre-assembled with connector panels, blank connector panels (for unused connector slots), strain relief, splice trays (as required) and splice incidentals. Fiber patch panels shall be complete with bulkheads as required to accommodate all fiber strands within the panel, and filler plates as required for all unused bulkhead slots (see Division 27 Specification Section Communications - Faceplates and Connectors), and with all incidental materials necessary for mounting.

a. Rack Mount Patch Panel: Rack mount patch panels shall be 19 inches wide and shall be available in 24/48 (1U), 48/96 (2U), and 72/144 (4U) port sizes.

b. Wall Mount Patch Panel: Wall mount patch panels shall be available in 24/48 port sizes.

2.3 COPPER TERMINATION BLOCKS

A. 66-Style:

1. Termination blocks:
   a. Provide designation strips for each 66M-style termination block, with bridge clips as required. Termination blocks shall be provided with or without 89-brackets as required by the mounting application. Designation strips shall mount on fanning strips of 66M block, provide a labeling surface for circuit identification, and be manufactured by the manufacturer of the 66M-block. Termination blocks shall be UL listed. Termination blocks shall be provided in the quantities required for complete termination. Provide as shown on the Drawings or as required.

   1) For voice-grade, Utility and QWEST backbone cable connectivity: Provide as shown on Drawings. Termination blocks shall be Category 3 rated or higher.

2.4 OTHER TERMINATION EQUIPMENT

A. Building Entrance Protectors: Provide Building Entrance Protectors (BEP’s) for the protection all building-to-building copper cables. Each BEP shall be provided complete (fully populated) with plug-in protector modules. Protector modules shall provide over-voltage and sneak current protection and shall be 4B series. For tail-in/tail-out style protectors, provide tail-in and tail-out lengths as required by the application. Provide in sizes and quantities as shown on the Drawings.

B. Splice Enclosures: Provide as shown on the Drawings and as required by Cable Spool length limitations.

   1. Copper Splice Enclosures: Splice enclosures shall be sized to accommodate the quantity of pairs to be spliced. Enclosures shall be re-enterable without the destruction of the housing. Enclosures shall be complete with all incidental and required hardware including, but not limited to, cans, end caps, grommet kits, covers, splice connectors, and grounding/bonding hardware. Enclosures shall be either butt or in-line depending upon the application and shall not require special tooling for entry and sealing of the enclosure.
a. Outdoors: Provide re-enterable encapsulant for all outdoor splice enclosures. The enclosure shall be encapsulated with a manufacturer recommended waterblocking compound.
b. Copper Splice Connectors: Splice connectors shall be RUS Listed and shall be either straight or bridge depending upon the application. Connectors shall be from the 3M 710 Splicing System.

PART 3 - EXECUTION

3.1 GENERAL
A. Work shall comply with the Governing Requirements as defined in Division 27 Specification Section Basic Communications Requirements. Governing Requirements of particular relevance to this Section include, but are not limited to:
1. TIA/EIA - 568: Commercial Building Telecommunications Cabling Standard
2. TIA/EIA 569: Commercial Building Standard for Telecommunication Pathways and Spaces
3. ANSI/EIA 310-D: Cabinets, Racks, Panels and Associated Equipment
4. TIA/EIA 606-A: The Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
5. ANSI J-STD-607: Commercial Building Grounding and Bonding Requirements for Telecommunications
6. TIA/EIA - 758: Customer-owned Outside Plant Telecommunications Cabling Standard

3.2 PATCH PANELS
A. Copper:
1. Horizontal Patch Panels: Cables shall be terminated sequentially and alphabetically by room number and sequential outlet number (within a room) left to right, from patch panel to patch panel (e.g. ports which terminate outlet cables from room 215A shall be terminated prior to ports which terminate outlet cables from room 220). Use the T568B wiring pattern.
2. Voice-Grade Copper Backbone Patch Panels: Cable pairs shall be terminated 1-pair per port sequentially in accordance with the United States color code.
3. Utility Distribution Cable Copper Backbone Patch Panels: Cable pairs shall be terminated 4-pairs per port sequentially in accordance with the United States color code.
B. Fiber:
1. Fiber Patch Panels: Strands shall be connected sequentially left to right and from top to bottom. Terminate singlemode fibers in first available ports and multimode in last available ports.

3.3 COPPER TERMINATION BLOCKS
A. Terminate cable sequentially across the termination strips. Punch down cable using only the Manufacturer approved impact tool.
B. Voice-grade, Utility and QWEST Backbone Termination Blocks: Cables shall be terminated by the United States Color Code and sequentially top to bottom and from left to right.

3.4 OTHER TERMINATION EQUIPMENT
A. Building Entrance Protectors (BEP’s): Install BEP’s for both ends of outside plant copper cables per manufacturer’s instructions. All outside plant copper cables shall be routed through BEP’s. Connect each BEP’s protector ground lug to the nearest TGB with #6 AWG copper grounding conductor.
B. Splice Enclosures:
   1. Copper:
      a. Grounding/Bonding: Cable shields/sheaths shall be connected together at all splices and termination points to assure a continuous metallic shield. Shield/sheath continuity shall be tested. Enclosure shall be connected to ground connectors if located in an underground cable vault/manhole/pullhole.
      b. Testing: Copper splices shall be electrically tested for opens, shorts, crosses and grounds, prior to sealing the enclosure.
## EQUIPMENT SCHEDULE - TE

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<td>VOICE-GRADE CABLE COPPER PATCH PANEL-CAT 5E (96 PORT, 4U)</td>
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<td>DATA-GRADE COPPER BACKBONE PATCH PANEL-CAT 6 (48 PORT, 2U)</td>
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END OF SECTION
SECTION 27 11 70
COMMUNICATIONS - ENCLOSURES

PART 1 - GENERAL

1.1 SUMMARY
   A. This Section includes requirements for providing equipment and materials for TIA/EIA compliant enclosures. General requirements for enclosures are covered in Division 27 Specification Section Communications – General Requirements.

1.2 RELATED SECTIONS
   A. The requirements of Division 27 Specification Section Communications - General Requirements shall serve as the basis for the requirements of this Section, and are incorporated by reference into this Section.

1.3 SUBMITTALS
   A. Comply with the Submittal portion of Division 27 Specification Section Basic Communications Requirements. Provide submittal information for the following:
      1. Product Data
      2. Shop Drawings:
         1) Wireless Access Point Enclosure: Provide only if locations have not been shown on the Drawings, or if the Contractor is proposing a deviation. Provide a separate Drawing for each type of Wireless Access Point enclosure to be installed.

PART 2 - MATERIALS

2.1 GENERAL
   A. Part Numbers: Refer to the equipment schedule at the end of this Section for specific part numbers. If no part number is provided, than any part meeting the requirements specified is acceptable.

2.2 WIRELESS ACCESS POINT ENCLOSURE
   A. Ceiling mount:
      1. Provide ceiling mount enclosures as shown on the Drawings. Enclosure shall be plenum rated, have a continuous hinge swing-down door with keyed lock, capable of mounting in a 2 foot by 2 foot or 2 foot by 4 foot ceiling tile opening. Enclosure shall be complete with fire-rated foam kits, mounting plate components and fittings as required for a complete installation.
   B. Wall Mount
      1. Provide wall mounted enclosures for Wireless Access Point (WAP) outlets as shown on the Drawings. Enclosure shall be a vented steel enclosure, have a continuous hinge swing down door with keyed lock, with two 1 inch antenna openings 5 inches apart located on the top of the enclosure. Coordinate color with Owner. Enclosure shall have knockouts for cable ingress/egress, and shall be constructed of vented steel 11 inches by 8 inches by 3 inches. Enclosure shall be complete with fire-rated foam/donut kits, mounting plate components and fittings as required for a complete installation.
PART 3 - EXECUTION

3.1 GENERAL

A. Work shall comply with the Governing Requirements as defined in Division 27 Specification Section Basic Communications Requirements. Governing Requirements of particular relevance to this Section include, but are not limited to:
1. TIA/EIA 568: Commercial Building Telecommunications Cabling Standard
2. TIA/EIA 569: Commercial Building Standard for Telecommunication Pathways and Spaces
3. TIA/EIA 606: The Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
4. TIA/EIA 607: Commercial Building Grounding and Bonding Requirements for Telecommunications
6. Manufacturer’s Installation Manual and Instructions

B. The Contractor shall pay particular attention to and comply with the following Owner Governing Requirements:
1. UCB Telecommunications Standards:
   (http://fm.colorado.edu/construction/standards/TelecommunicationsStandards.html)

3.2 WIRELESS ACCESS POINT ENCLOSURE

A. Coordinate final enclosure locations with Owner after Owner has performed a wireless survey.

B. Install enclosures for wireless access equipment per manufacturer’s recommendations, including all accessories necessary and firestop materials.

C. Secure with toggle bolts when wireless wall enclosures are installed on gypsum board.

D. Wireless access point enclosures must comply with the UCB Wireless Ceiling and Wall Security Box Instructions.

E. Place one self tapping screw to ceiling grid through each of the support arms when ceiling enclosures are installed.
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</table>

END OF SECTION
SECTION 27 13 00
COMMUNICATIONS - BACKBONE CABLING

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes requirements for backbone cable within the Communications Cabling System. General requirements for backbone cable are covered in Division 27 Specification Section Communications - General Requirements.

1.2 RELATED SECTIONS
A. The requirements of Division 27 Specification Section Communications - General Requirements shall serve as the basis for the requirements of this Section, and are incorporated by reference into this Section.

1.3 SUBMITTALS
A. Comply with the Submittal portion of Division 27 Specification Section Basic Communications Requirements. Provide submittal information for the following:
   1. Product Data

PART 2 - MATERIALS

2.1 GENERAL
A. Manufacturer: Unless otherwise indicated, equipment and materials in this Section shall be of the same Manufacturer as that specified under Division 27 Specification Section Communications - General Requirements.

B. Part Numbers: Refer to the equipment schedule at the end of this Section for specific part numbers. If no part number is provided, then any part meeting the requirements specified is acceptable.

2.2 COPPER
A. General:
   1. Cable shall be multi-pair 24 AWG solid copper conductors insulated with color coded PVC, and shall be sized in pair counts as shown on the Drawings.
   2. Copper cable ratings shall be as specified under Division 27 Specification Section Communications - General Requirements.

B. Inside Plant (Interior): Provide indoor rated cable.
   1. Inside Plant Riser (Voice-grade, Utility and QWEST) Multi-Pair Backbone: Provide as shown on the Drawings. Cable shall be unshielded.

C. Outside Plant (Exterior): Provide outdoor rated cable. Cable shall conform to RUS PE-89, shall be single jacketed, shielded, and provided as follows:
   1. For Conduit/Duct Installation: Cable shall be armored and flooded (insulated with filling compound).
2.3 **COAXIAL CATV**

A. General: Coaxial cable shall be 75 ohm cable, solid conductor. Cable shall be sized as shown on the Drawings.

B. Inside Plant (Interior): Provide indoor rated cable.
   1. Backbone / Trunk:
      a. All coaxial backbone cable shall be 0.500 non-flooded cables. Campus tunnel systems are used for coaxial backbone pathways. The tunnels are considered environmentally controlled environments; coaxial cables with built-in flooding compounds are not required. Plenum rated cable is only to be used where and when required. Type RG-11 coaxial cable shall not be permitted in this application.
      b. Hardline: Cable shall be hardline, copper clad aluminum center conductor with an aluminum tube shield with insulating jacket.
         1) Riser Rated Non-Plenum (CMR or CATVR) .500 non-flooded cable Times Fiber T10500J
         2) Riser Rated Plenum (CMP or CATVP) .500 non-flooded cable Commscope P3 500 JCAP
      c. Connectors used for terminations:
         1) Corning / Gilbert connectors are recommended and preferred

2.4 **FIBER**

A. General: Provide fiber optic cable in quantities, strand counts, and types (singlemode, multimode, or hybrid) as shown on the Drawings. Fiber cable shall be all-dielectric, shall conform to Bellcore and RUS standards, and shall be as further specified under Division 27 Specification Section *Communications - General Requirements*.

B. Inside Plant (Interior): Provide indoor rated cable. Cable shall be tight buffered.

C. Outside Plant (Exterior): Provide loose buffered (loose tube) with a dielectric central strength member. Fibers shall be separated into binder groups inside a central tube gel-filled with water-blocking compound.

**PART 3 - EXECUTION**

3.1 **THIS SECTION NOT USED**
## EQUIPMENT SCHEDULE - BC

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<th>Special Rqmt</th>
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<tr>
<td>BC010</td>
<td>ISP COPPER BACKBONE (RISER)</td>
<td>M5xxxx</td>
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<td>BC110</td>
<td>ISP COPPER BACKBONE</td>
<td>see Special Rqmt</td>
<td>Belden ANMW-xxx</td>
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</table>
| BC200| ISP COAXIAL/ CATV TRUNK (HARDLINE)    | see Special Rqmt | Plenum: COMMScope P3 500 JCAP  
Non-plenum: Times Fiber T10500J |
| BC410| ISP MM FIBER FIRE ALARM ONLY (62.5 MICRON) | see Special Rqmt | Systimax 520x-002A-MxSL |
| BC420| ISP MM FIBER BACKBONE (50 MICRON, LASER OPTIMIZED) | see Special Rqmt | Systimax 5200 xxxA ZxAQ |
| BC450| ISP SM FIBER BACKBONE                 | see Special Rqmt | Systimax ABC-xxx-SRX  |
| BC510| OSP MM FIBER BACKBONE (62.5 MICRON)   | see Special Rqmt | Systimax 5022-xxxA-MXBK |
| BC550| OSP SM FIBER BACKBONE                 | see Special Rqmt | Systimax 5022-xxxA-WXBK |

END OF SECTION
SECTION 27 15 00
COMMUNICATIONS - HORIZONTAL CABLE

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes specific requirements for horizontal cable within the Communications Cabling System. General requirements for horizontal cable are covered in Division 27 Specification Section Communications - General Requirements.

1.2 RELATED SECTIONS
A. The requirements of Division 27 Specification Section Communications - General Requirements shall serve as the basis for the requirements of this Section, and are incorporated by reference into this Section.

1.3 SUBMITTALS
A. Comply with the Submittal portion of Division 27 Specification Section Basic Communications Requirements. Provide submittal information for the following:
1. Product Data

PART 2 - MATERIALS

2.1 GENERAL
A. Manufacturer: Unless otherwise indicated, equipment and materials in this Section shall be of the same manufacturer as that specified under Division 27 Specification Section Communications - General Requirements.

B. Part Numbers: Refer to the equipment schedule at the end of this Section for specific part numbers. If no part number is provided, then any part meeting the requirements specified is acceptable.

2.2 COPPER
A. Horizontal Cable: Cable shall be 4 pair UTP, solid copper conductors insulated with color coded PVC. Copper cable Category rating shall be the same as that specified under Division 27 Specification Section Communications - General Requirements.
1. Color shall be:
   a. Voice and Data: Category 5e – Blue
   b. Access Control System: Category 5e – Purple
   c. Wireless Access Point: Category 6 – Yellow

2.3 COAXIAL CATV
A. Coaxial horizontal cable shall be:
1. 75 ohm, Series 6, 18 AWG solid conductor, low loss, 60% braided shield.
   a. Inside Rated (CM or CATV), Times Fiber 2360V
   b. Plenum Rated (CMP or CATVP), CommScope 2275V
2. Connectors used for terminations shall be:
   a. Thomas and Betts Snap-N-Seal or Ideal / Stirling SPL
PART 3 - EXECUTION

3.1 GENERAL

A. Refer to UCB Jack Numbering Document for further information.
## EQUIPMENT SCHEDULE - HC

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<td>HC100</td>
<td>HORIZONTAL COPPER CABLE (CAT5E)</td>
<td>Mohawk M575xx</td>
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<tr>
<td>HC100</td>
<td>HORIZONTAL COPPER CABLE (CAT6)</td>
<td>Mohawk M57xxx</td>
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<tr>
<td>HC200</td>
<td>HORIZONTAL COAX CABLE (CATV)</td>
<td>See Special Reqmt</td>
<td>Plenum-CommScope 2276V Non-Plenum-Times Fiber 2360V</td>
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END OF SECTION
SECTION 27 15 43
COMMUNICATIONS - FACEPLATES AND CONNECTORS

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes requirements for faceplates and connectors within the Communications Cabling System. General requirements for faceplates and connectors are covered in Division 27 Specification Section Communications - General Requirements.

1.2 RELATED SECTIONS
A. The requirements of Division 27 Specification Section Communications - General Requirements shall serve as the basis for the requirements of this Section, and are incorporated by reference into this Section.

1.3 SUBMITTALS
A. Comply with the Submittal portion of Division 27 Specification Section Basic Communications Requirements. Provide submittal information for the following:
   1. Product Data

PART 2 - MATERIALS

2.1 GENERAL
A. Manufacturer: Unless otherwise indicated, equipment in this Section shall be of the same Manufacturer as that specified under Division 27 Specification Section Communications - General Requirements.
B. Part Numbers: Refer to the equipment schedule at the end of this Section for specific part numbers. If no part number is provided, then any part meeting the requirements specified is acceptable.

2.2 FACEPLATES
A. General: Provide faceplates for outlets in the locations and gang counts as shown on the Drawings or as specified below. Faceplates shall be complete with blank inserts/fillers for covering unused connector openings. Faceplates and fittings shall be dimensionally suitable for securely mounting connectors, providing a snug and sure fit – loose connectors are not acceptable. Faceplates shall be complete with port identification labels, and shall be provided with appropriate adapters, fittings and adapters as required.
B. Color: The color of non-stainless steel faceplates shall be electric ivory unless specified below.
C. Faceplates/Fittings:
   1. For wall-mount telephone locations:
      a. Faceplates shall be brushed stainless steel with stainless steel mounting lugs suitable for mounting wall-mount telephones. Faceplates shall be dimensionally suitable for securely mounting 8-position/8-conductor IDC (RJ45 style) connectors.
2. For specialized mounting requirements (including but not limited to furniture, furniture “pop-ups” and enclosures, floor-boxes, poke-throughs, surface mounted raceway, etc.):
   a. Provide faceplates and fittings as required to support the specialized mounting. Faceplates and fittings shall be manufactured specifically for the equipment that they are to be mounted into (“general purpose” faceplates field modified for the specialized use are not acceptable unless specifically noted otherwise on the Drawings). Faceplates and fittings shall be approved by both the equipment manufacturer and the communications cabling system manufacturer, and shall be coordinated and verified compatible by the Contractor, equipment manufacturer and cabling system manufacturer prior to procurement and delivery. The provision of the correct faceplates and fittings for use in specialized mounting requirements is the sole responsibility of the Contractor.

3. For Wireless Access Enclosure:
   a. Provide low profile surface housing.

4. For walls and other non-specialized locations:
   a. Faceplates shall be plastic and capable of flush-mounting connectors.
   b. Standard single gang faceplates shall have six jack openings.

5. For Security Camera (SC) locations:
   a. Provide surface housing outlet box. Surface housing shall be dimensionally suitable for securely mounting 8-position/8-conductor IDC (RJ45 style) connectors.

D. Provide blank faceplates, matching those faceplates in use, for all unused communications backboxes.

2.3 CONNECTORS

A. General: Connectors shall meet or exceed the TIA/EIA standards and as called for in the Governing Requirements.

B. Horizontal:
   1. Copper: Copper connectors shall be 8-position/8-conductor, insulation displacement connector (IDC), non-keyed, and shall accept modular 8-position/8-conductor plugs. Connectors shall have a universally color-coded wiring pattern for both T568A and T568B. Copper connectors Category rating shall be the same as that specified under Division 27 Specification Section Communications - General Requirements. Colors shall be:
      a. Voice and Data: Category 5e – Gray
      b. Wireless Access Points: Category 6 – Yellow
      c. Cameras: Category 6 – Red
   2. Coaxial CATV:
      a. Connectors shall be compression F-type.

C. Backbone:
   1. Coaxial CATV: Connectors shall be as shown on Drawings.
   2. Fiber: Fiber connectors shall be complete with bulkheads, adapters and adapter plates where required for mounting in fiber patch panels. Connectors shall be specific to the fiber core size to be connectorized and shall be:
      a. Inside Plant:
         1) Multimode: SC (50/125 LO)
         2) Singlemode: ST
      b. Outside plant:
         1) Multimode: ST
         2) Singlemode: ST
      c. Provide direct termination kit for outside plant cables.
PART 3 - EXECUTION

3.1 FACEPLATES
A. Install all faceplates level and perpendicular to the floor. If long side of existing outlet box is mounted horizontal, then rotate faceplate counter-clockwise.

3.2 CONNECTORS
A. Horizontal:
   1. Copper: Terminate connectors using the T568B wiring pattern at both ends of the cable.
   2. Coaxial CATV: Connectorize coaxial cable strictly according to Manufacturers instructions using manufacturer specified tools.

B. Backbone:
   1. Copper:
      a. Comply with Division 27 Specification Section Communications - Termination Equipment.
   2. Coaxial CATV: Connectorize coaxial cable strictly according to Manufacturers instructions using manufacturer specified tools.
   3. Fiber: Connectorize fiber strictly according to Manufacturers instructions using manufacturer specified tools and termination kits. All fiber strands within a cable shall be connectorized – the installation of “dark fiber” is not acceptable unless shown otherwise on Drawings.
      a. Connectors: Visually verify connectorization after installation with a minimum 200x magnification microscope to ensure that no physical damage has occurred during the installation process.
      b. Utilize a direct termination kit for outside plant cables.
## EQUIPMENT SCHEDULE - FC

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<td>FC010</td>
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<td>FC020</td>
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<td>SURFACE HOUSING FOR WIRELESS ACCESS OUTLET</td>
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<td>FC050</td>
<td>PLASTIC FACEPLATE</td>
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<td>HXJEEx</td>
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<td>See Special Rqmt</td>
<td>Gilbert P3 series</td>
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<td>FC205</td>
<td>COAXIAL CONNECTOR - HORIZONTAL (CATV)</td>
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<td>T&amp;B Snap-N-Seal or Stirling SPL</td>
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<td>FC360</td>
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<td>See Special Rqmt</td>
<td>Systimax D-181755</td>
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**END OF SECTION**
SECTION 27 16 19
COMMUNICATIONS - PATCH CORDS

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes specific requirements for communications patch cords within the Communications Cabling System. General requirements for patch cords are covered in Division 27 Specification Section Communications - General Requirements.

1.2 RELATED SECTIONS
A. The requirements of Division 27 Specification Section Communications - General Requirements shall serve as the basis for the requirements of this Section, and are incorporated by reference into this Section.

1.3 SUBMITTALS
A. Comply with the Submittal portion of Division 27 Specification Section Basic Communications Requirements. Provide submittal information for the following:
   1. Product Data

PART 2 - MATERIALS

2.1 GENERAL
A. Manufacturer: Unless otherwise indicated, equipment and materials in this Section shall be of the same manufacturer as that specified under Division 27 Specification Section Communications - General Requirements.

B. Part Numbers: Refer to the equipment schedule at the end of this Section for specific part numbers. If no part number is provided, then any part meeting the requirements specified is acceptable.

2.2 COPPER PATCH CABLES
A. Provide copper patch cables for modular copper cross-connects. Patch cables shall be pre-manufactured (factory-terminated), stranded UTP, with 8-pin modular plugs.
   1. Refer to UCB Telecommunications Standards: (http://www.colorado.edu/facilitiesmanagement/pdc/construction/standards/documents/Division27CommunicationsSpecifications.pdf) for installation of patch cords.
   2. Patch cables shall be 4-pair with bootless modular plugs. Copper patch cables Category rating shall be the same as that specified under Division 27 Specification Section Communications - General Requirements.
      a. EF and TR: Provide one (1) patch cord for each new horizontal cable. Coordinate color and exact length (10-foot maximum) with Owner prior to ordering patch cords.
      b. For Work Area Outlets (Workstation):
         1) Data and Voice Port: Provide one (1) Category 5e desktop patch cord for each cable in the second through sixth position on the faceplate. Coordinate color (for bidding purposes assume blue for voice and black for data) and exact length (10-foot maximum) with Owner prior to ordering patch cords.
2) Wireless Access Points and Security Cameras: Provide one (1) Category 6 desktop patch cord for each Wireless Access Point and each Security Camera. Coordinate color and exact length (10-foot maximum) with Owner prior to ordering patch cords

2.3 FIBER PATCH CABLES
1. Fiber patch cables will be provided by Owner.

PART 3 - EXECUTION

3.1 PATCH CORD INSTALLATION

A. Refer to UCB Telecommunications Standards: (http://www.colorado.edu/facilitiesmanagement/pdc/construction/standards/documents/Division27CommunicationsSpecifications.pdf) for installation of patch cords.

B. Provide 4-pair modular patch cords for ER/TR and Work Area Outlets to Owner 3 weeks prior to final acceptance.

C. Coordinate termination plan with Owner prior to ordering patch cords. The Contractor shall submit the pair count with the jack number for as-built documentation at three weeks and at one week prior to occupancy or as specified by Owner.
### EQUIPMENT SCHEDULE - PC

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<td>COPPER PATCH CORD, NO BOOT (CAT5E), SPECIAL</td>
<td>PC5EXYxx</td>
<td>Special Circuit Cord Colored Yellow for Circuits other than Voice or Data in TR and ER</td>
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<tr>
<td>PC100</td>
<td>COPPER PATCH CORD (CAT6)</td>
<td>PC6Exyy</td>
<td>Replace 'Y' with color description and 'yy' with length</td>
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</tbody>
</table>

END OF SECTION
SECTION 27 17 15
COMMUNICATIONS - TESTING, IDENTIFICATION AND ADMINISTRATION

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes requirements for testing and identification/administration of the Communications Cabling System.

1.2 UCB REQUIREMENTS AND STANDARDS

A. The Contractor shall comply with the following UCB requirements and standards:
   1. UCB Telecommunications Standards, Section 271700 – Testing, Identification and Administration.

B. In the event of conflict/disagreement between UCB Telecommunications Standards and this Specification Section, the more stringent condition shall prevail.

1.3 SUBMITTALS

A. Comply with the Submittal portions of Division 27 Specification Sections Basic Communications Requirements and Communications - General Requirements. Provide submittal information for the following submittal sections below:
      a. Provide a list of proposed test equipment for use in verifying the installation of the communications cabling system.
         1) Provide for each testing device:
            a) Manufacturer and product number.
            b) Manufacturer documentation showing date and outcome of last re-calibration. Testing device shall have been re-calibrated within the manufacturer’s recommended recalibration period.
            c) Manufacturer documentation showing software revision. Software revision shall be most current revision available for the device and shall be based upon the most current TIA/EIA testing guidelines.
            d) Patch cords and other specialized components.
      b. Provide the calculated optical fiber cable loss budget for each optical fiber cable in the system (see Part 3 – Execution: Testing herein)
   2. Identification and Administration (see Part 2 – Materials: Identification and Administration herein):
      a. Provide a list of proposed hand-carried or computer software based identification/label makers, and a list of proposed materials for identifiers/labels.
      b. Provide actual samples of labels to be created for each system component to be labeled.
      c. Complete and submit the UCB-provided T5 template spreadsheet designating all outlet and jack numbering.
         1) Spreadsheet shall be complete prior to installation.
         2) Update UCB-provided T5 template spreadsheet designating all outlet and jack numbering and submit to UCB three weeks prior to move-in date. The revised T5 submittal shall incorporate any changes from the original project design.
PART 2 - MATERIALS

2.1 TESTING

A. General
1. Testing of the systems shall be in accordance with the manufacturer’s recommendations and with the Governing Requirements.
2. Test reports shall be complete and in accordance with the appropriate Governing Requirements.
3. Where testing discloses deficiencies in the work, the Contractor shall rework, repair, or replace equipment and systems found deficient. The Contractor shall continue remedial measures and retesting until satisfactory results are obtained. Remedial measures and retesting shall be at no additional cost to UCB.
4. Testing of product or equipment prior to installation shall include performance testing to establish the applicability of equipment for its intended purpose. The Contractor shall:
   a. Establish the required test procedures from required Governing Requirements and manufacturer’s recommendations.
   b. Provide necessary test equipment, power, and consumables to perform the test.
   c. Notify the Engineer of test schedule(s) at least one week in advance.
   d. Perform test.
   e. Provide test result documentation to the Engineer.
5. Final testing and start-up of product, equipment, and systems shall include establishing proper capacity, operation, maintenance, and compliance with Governing Requirements. The Contractor shall:
   a. Provide the services of manufacturer’s representatives for systems to be tested and started up.
   b. Establish the required test procedures from required Governing Requirements and manufacturer’s recommendations.
   c. Provide necessary test equipment, power, and consumables to perform the test.
   d. Notify the Engineer of test schedule(s) at least one week in advance.
   e. Perform tests and start-up functions.
   f. Provide documentation of test results and fully operational systems to the Engineer.
6. Test records shall be provided on a form approved by the Engineer.

B. Systems Specific: Test shall be performed for each of the following systems as follows:
1. Communications Cabling System
   a. Test records:
      1) Each cable in the system shall be tested. Test result forms shall include the cable identifier, tests performed, outcome of tests and indication of errors found, cable length, retest results, and name and signature of technician completing the tests. Test result forms shall be provided to UCB and Engineer for review and acceptance.
      2) Test records for each cable within the system shall be printed directly from the tester and shall be submitted in paper form (in a binder) and on compact disc to UCB and Engineer for review. Handwritten test results will not be accepted.
   b. Testing Devices: Testing devices shall be capable of storing and printing test records for each cable within the system.
      1) For copper cables:
         a) Testing device shall meet the following requirements for a level 3 ANSI/TIA/EIA-568-B.2 Annex B and Annex testing instrument:
            i. Be re-calibrated within the calibration period recommended by the manufacturer, with the most current software revision based upon the most current TIA/EIA testing guidelines.
ii. Physical interface shall be modular RJ-45 and a serial port with DB-9 connector.
iii. Store test results including date stamp of tests and UCB jack designator for each tested link.
iv. Print test results in report form when connected to a PC.
vi. Measure NEXT for all pair combinations and attenuation on all pairs from 1.0 to 350 MHz.

2) For fiber cables:
   a) Field test instruments for multimode fiber cabling shall meet the requirements of ANSI/TIA/EIA-526-14A.
   b) Field test instruments for singlemode fiber cabling shall meet the requirements of ANSI/TIA/EIA-526-7.
   c) Multimode light source shall:
      i. Meet the launch requirements of ANSI/TIA/EIA-455-50B achieved within the field test equipment or by use of an external mandrel wrap (as described in clause 11 of ANSI/TIA/EIA-568-B.1) with a Category 1 light source.
      ii. Provide stabilized 850 nm and 1300 nm +/- 20 nm wavelength LED light source.
      iii. Have spectral width of sources of <50 nm of 850 nm wavelengths and < 140 nm for 1300 nm wavelengths.
      iv. Have output of light sources of 8 MW for 62.5 or 50 nm core optical fiber as appropriate.
      v. Shall have an output stability of +/- 0.40 dB from 0 to 50 degrees C.
      vi. Shall have long term output stability of +/- 0.10 dB at 25 degrees C.
      vii. Shall support ST and SC connector types.
   d) Singlemode light source shall:
      i. Provide stabilized 1310 nm and 1500 nm +/- 20 nm wavelength laser light source.
      ii. Shall have an output stability of +/- 0.40 dB from 0 to 50 degrees C.
      iii. Shall have long term output stability of +/- 0.10 dB at 25 degrees C.
      iv. Shall support ST connectors.
   e) Optical power meter shall:
      i. Be calibrated against National Institute of Standards and Technology (NIST) standard.
      ii. Shall provide 850 nm and 1300 nm +/- 20 nm selectable wavelength test capability.
      iii. Shall have a measurement range of 10 to -60 dBm.
      iv. Shall have an accuracy of +/- 5 percent at 0 to 50 dBm.
      v. Shall have an accuracy of +/- 10 percent at 10 to 0 dBm and -50 to -60 dBm.
      vi. Shall have a resolution of 0.01 dB.
      vii. Shall support ST and SC connector types.
   f) Optical time domain reflectometer shall:
      i. Have dual selectable wavelength (850/1300 nm for multimode, 1310/1500 nm for multimode.
      ii. Have selectable cable index of refraction.
      iii. Shall have a visual fault locator for continuity checks and dead zone fault location.
      iv. Shall have a front display and printer connection for hard-copy documentation.
      v. Shall be equipped with launch jumper cable of sufficient length to offset entry “dead zone”.
      vi. Shall support ST and SC connector types.
To ensure quality connectorization, a microscope of not less than 200x magnification shall be used to visually inspect connectors and splices after installation.

2.2 IDENTIFICATION AND ADMINISTRATION

A. Identifiers (labels) shall be as recommended in TIA/EIA 606-A, unless noted otherwise herein.

B. Identifiers (labels) shall be as determined by and coordinated with UCB.

C. Labels shall be permanent (i.e. not subject to fading or erasure) and permanently affixed. Handwritten labels are not acceptable.

D. For identification of materials and equipment interior to the facility:
   1. Faceplate labels: Labels shall be created with a hand-carried label maker (Dymo Electronic Labelmaker 5000 or equivalent) or an equivalent computer/software-based label making system.
   2. Termination sheets and labels for copper and fiber terminations and enclosures: to be provided by UCB ITS and installed by the Contractor. Replacement sheets and labels will be provided to the Contractor at an additional cost.
   3. Cable Marking: Label shall be a vinyl substrate with a while printing area and a clear “tail” that self laminates the printed area when wrapped around the cable. If cable jacket is white, provide cable label with printing area that is any other color than white (preferably orange or yellow), so that the labels are easily distinguishable.
   4. Pre-printed labels shall meet legibility, defacement, exposure and adhesion requirements of UL 969.
   5. Hand written labels shall not be acceptable.

E. For identification of materials and equipment in the outside plant:
   1. Labels shall be waterproof (even when submerged) and engraved on hard plastic markers. Lettering shall be black, markers shall be white.

PART 3 - EXECUTION

3.1 GENERAL

A. Work shall comply with the references and standards listed in Specification Section – Communications - General Requirements.
   1. Testing:
      a. TIA/EIA - 455: Fiber Optic Test Standards
      b. TIA/EIA - 526: Optical Fiber Systems Test Procedures
      c. TIA/EIA - 568 Commercial Building Telecommunications Cabling Standard
      d. IEEE 802.3 (series): Local Area Network Ethernet Standard, including the IEEE 802.3z Gigabit Ethernet Standard
   2. Identification and Administration:
      a. TIA/EIA 606-A: The Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
      b. UCB Telecommunications Standards - Jack Numbering Document (http://decker.colorado.edu/standards)
      c. UCB Telecommunications Standards - Construction Drawings As-built Rules (http://decker.colorado.edu/standards)
3.2 TESTING

A. General

1. Test devices shall be in calibration throughout the testing period. Tests performed on equipment without up-to-date calibration shall be rejected and shall be repeated at no additional cost to UCB.

2. The Contractor shall notify the Engineer and UCB 7 days in advance of each type of test to be conducted. UCB or Engineer may, at their discretion, witness all testing.
   a. UCB and Engineer shall be invited to attend and inspect the first instance of each type of test to be conducted. Tests conducted prior to first inspection shall be at the sole risk of the Contractor, and as such are subject to rejection. Such tests will be repeated at no additional cost to UCB.

B. Systems Specific Testing:

1. Communications Cabling System
   a. All interior (inside plant) and exterior (outside plant) fiber cables shall be tested on the reel upon delivery to the job site prior to installation.
      1) Test results shall be permanently affixed to the reel and a copy given to UCB and Engineer for review prior to installation.
      2) Testing shall demonstrate compliance with the factory test results as shipped with the reel. Cables that fail to pass shall not be installed, and the Contractor shall replace the cable at no additional cost to UCB. Repair of damaged cable is not acceptable.
   b. The Contractor shall perform pre-testing of the installed telecommunications systems to determine compliance and notify UCB ITS personnel when the system is ready for final inspection and testing. UCB shall be obligated to schedule final inspection and testing within five (5) business days of notification by the contractor. Final testing shall be scheduled and conducted in the presence of the UCB ITS representative.
   c. Test sheets for communication jacks will not be supplied to the Contractor by UCB ITS. The Contractor shall comply with the most current Hubbell Mission Critical Warranty documentation and procedure. All documentation including, but not limited to the “Structural Cabling System Registration Request Form”, “testing disk”, “Horizontal Schematic”, and “Backbone Schematic” shall be completed in full and shall include the installer’s full name, company name, telephone number, date completed, and UCB jack outlet with faceplate port numbers (e.g. 202-1A-1C). All documentation shall be provided to both Hubbell and the University of Colorado ITS for warranty. The testing disk to UCB ITS shall be converted to a text format. Unless specified otherwise, submit testing results in as-built submittals of this information no later than 4 weeks following project completion. This project may be subject to submittal on a monthly basis as determined by UCB ITS.
   d. Test the communications cabling system for compliance to the Governing Requirements and all applicable standards as follows:
      1) Visually inspect all labels at the outlet locations (faceplates/ports), patch panels/ports, and on each end of each cable to ensure that all cables and equipment are correctly identified.
      2) Copper Cable:
         a) For Horizontal Distribution: Test each copper horizontal cable, all pairs. To the extent possible, tests shall be performed with building electrical systems fully powered on (i.e. Lights, HVAC, etc.).
i. Test each end-to-end Permanent Link (the entire link from the connector at the outlet to the connector or termination in the telecommunications closet) utilizing sweep tests, for Wire map (continuity), length, propagation delay/delay skew, attenuation (insertion loss), return loss, near-end cross talk (NEXT) loss, Equal Level Far-End Crosstalk (ELFEXT), attenuation-to-crosstalk ratio (ACR), power sum NEXT (PSNEXT) and power sum ELFEXT (PSELFEXT). Each cable shall be tested in both directions.
   (a) Measure NEXT for all cable pair combinations and attenuation on all pairs from 1.0 to 350 MHz.

ii. Test results shall demonstrate compliance with:
   (a) The criteria specified in TIA/EIA 568 for Category 5e and 6 cables
   (b) The criteria specified in TIA/EIA TSB 95, and TIA/EIA 568-A-5
   (c) The criteria specified in IEEE 802.3z (1000Base-X Gigabit Ethernet)

b) For Backbone Distribution (inside and outside plant): Test each cable, all pairs, for length, shorts, opens, continuity, polarity reversals, transposition (wire map), and the presence of AC voltage.

i. Test entire channel, from termination block to termination block.

ii. Test results shall demonstrate compliance with:
   (a) The criteria specified in TIA/EIA 568 for Category 3 cables

3) Fiber Cable:
   a) Prior to testing, the cable loss budget shall be calculated by the Contractor for each optical fiber cable and shall be clearly shown on the test documentation. Maximum loss shall be calculated by the following formula, assuming no splices:
      i. For Backbone Distribution (inside and outside plant):
         (a) \[ \text{Max Loss} = \left( \frac{\text{allowable loss/km}}{\text{km of fiber}} \right) + 0.4\text{db} \times \# \text{ of connectors} \]
         (b) A mated connector-to-connector interface is defined as a single connector for the purposes of the above formula.
      ii. A given fiber cable shall not exceed its calculated maximum loss (per the above formula).
   b) Test all strands. Testing shall consist of a bi-directional end-to-end Optical Transmission Loss Test Instrument trace performed per TIA/EIA 455-61 and a bi-directional end-to-end power meter test performed per TIA/EIA 455-53A.
      i. Loss numbers shall be calculated by taking the sum of the two bi-directional measurements and dividing that sum by two.
      ii. All backbone fiber cables shall be tested with an OTDR in addition to attenuation testing performed with a power meter.
         (a) The number of samples (averages) for each OTDR test shall be such that the noise amplitude is significantly less than the smallest loss of any component under test.
      iii. Multimode fiber testing shall incorporate use of a mandrel wrap of fiber jumper to induce macro bends in the fiber.
   c) Test measurements shall be provided as follows:
      i. For Multimode Cable: Test at both 850 and 1300nm.
      ii. For Singlemode Cable: Test at both 1300 and 1550nm.
   d) Test results shall demonstrate compliance with:
      i. The criteria specified in TIA/EIA-568A Annex H.
      iii. The criteria specified in ANSI/TIA/EIA-568-B.1, Section 11.3.3, Table 11-15.
      iv. The criteria specified in ANSI/TIA/EIA-526-7, Method A.1, One Reference Jumper.
      v. The Contractor’s calculated loss budget above.
      vi. The criteria specified in IEEE 802.3z (1000Base-X Gigabit Ethernet).
e. In addition to the above, tests performed shall be both those recommended and mandated by the communications cabling system manufacturer.

f. Cables and equipment that do not pass shall be identified to the Engineer. The source of the non-compliance shall be determined, corrected or replaced, and re-tested at no additional cost to UCB. Provide new test results to the Engineer in the same manner as above.

1) In addition to the above, if it is determined that a cable is at fault, the contractor shall remove the damaged cable and replace it with a new cable. Cable “repairs” are not acceptable. The procedure for removing the cable shall be as follows:
   a) Prior to removal of the damaged cable and re-pull of the new cable:
      i. Any cables which are in the same conduit, duct or innerduct as the damaged cable shall be tested, regardless of whether or not they are new cables installed as part of this project or existing cables installed prior to this project.
      ii. If the damaged cable is a backbone or outside plant cable:
          (a) UCB and Engineer shall be informed of the schedule for the removal and re-pull.
          (b) The new cable shall be tested on the reel prior to installation.
      iii. All test results shall be provided to the Engineer for approval.
   b) The damaged cable shall be removed and the new cable shall be pulled in.
   c) After the removal of the damaged cable and re-pull of the new cable:
      i. The new cable shall be tested.
      ii. Any cables which are in the same conduit, duct or innerduct as the damaged cable shall be tested, regardless of whether or not they are new cables installed as part of this project or existing cables installed prior to this project.
      iii. All test results shall be provided to the Engineer for approval.
   d) Existing cables which are in the same conduit, duct or innerduct as the damaged cable, and which are damaged by the extraction and re-pull process, shall be removed and replaced at no additional cost to UCB.
      i. Existing damaged cables that are replaced shall be subject to the testing procedures of this section in its entirety.

2) The contractor shall perform pre-testing of the installed telecommunications systems to determine compliance and notify UCB ITS personnel when the system is ready for final inspection and testing. UCB shall be obligated to schedule final inspection and testing within five (5) business days of notification by the contractor. Final testing shall be scheduled and conducted in the presence of the UCB ITS representative.

3.3 IDENTIFICATION AND ADMINISTRATION

A. General
   1. The UCB standard outlet numbering plan to be used for labeling faceplates, 66-blocks, patch panels, and fiber terminations shall be as described in UCB document Labeling and Testing.
   2. The Contractor is solely responsible for the completeness, accuracy, and placement of identifiers (labels). Incorrectly identified components are the sole responsibility of the Contractor.
      a. Identification and labeling for all copper and fiber optic cable terminations shall be coordinated with UCB ITS staff.
      b. Where questions arise regarding the correct identifier for a given component, the Contractor shall notify UCB ITS and Engineer and await direction prior to proceeding.
   3. The Contractor shall install identifiers where indicated and at locations for best viewing convenience without interfering with the operation and maintenance of equipment.
   4. The Contractor shall coordinate names, abbreviations, colors, and other designations with the corresponding designations indicated in the Construction Documents and as required by UCB, codes and standards.
   5. The Contractor shall use consistent identifiers throughout the Project.
6. The Contractor shall clean surfaces of dust, loose material, and oily films before applying self-adhesive identifiers.
7. All copper and fiber optic cables shall be neatly and permanently labeled with the cable number at both ends.
8. Two weeks prior to a particular component or group of components being labeled, the Contractor shall review the proposed identification scheme, label(s), and procedure for affixing label(s) with UCB and Engineer. Contractor shall not proceed with labeling until UCB and Engineer have approved the proposed identification scheme, label(s), and procedure for affixing label(s).
9. The Contractor shall physically verify that the component to be identified matches the label to be affixed, prior to affixing the label.

B. The telecommunications rooms and spaces shall be labeled and 3 weeks prior to testing, including the outlet numbers on the patch panels as soon as the racks are installed) to allow pre-inspections.

C. UCB Jack Numbering Spreadsheet
1. Contractor shall complete UCB-provided T-5 template for Jack Numbering within 2 weeks of award. Additional T-5 lists shall be submitted to UCB for more than 5 additions or 5 deletions throughout the Project.
2. Contractor shall submit an updated UCB T-5 template three weeks prior to scheduled move-in date. The revised T-5 submittal shall incorporate any changes from the original project design.
3. Contractor shall submit an updated UCB T-5 template one week prior to occupancy, or as agreed on per the project schedule with UCB ITS. The T-5 template shall be provided in hard copy and electronic copy.
4. Contractor shall post an Owner-approved final copy of UCB T-5 template in each applicable Telecommunications Room prior to occupancy.

END OF SECTION
SECTION 27 18 05
COMMUNICATION - MODULAR FURNITURE OUTLET BOXES

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes specific requirements for modular furniture boxes within the Communications Pathway System. General requirements are covered in Division 27 Specification Section Electrical - General Requirements.

1.2 RELATED SECTIONS
A. The requirements of Division 27 Specification Section Electrical - General Requirements shall serve as the basis for the requirements of this Section, and are incorporated by reference into this Section.

PART 2 - MATERIALS

2.1 GENERAL
A. Part Numbers: Refer to the equipment schedule at the end of this Section for specific part numbers. If no part number is provided, or specified part is incompatible with modular furniture provided by Owner, then part(s) shall be coordinated with Owner prior to procurement.

2.2 RECEPTACLE (OUTLET) BOXES
A. Provide receptacle (outlet) boxes as required to support the specialized mounting. Receptacle boxes shall be approved by both the equipment manufacturer and the communications cabling system manufacturer, and shall be coordinated and verified compatible by the Contractor, equipment manufacturer and cabling system manufacturer prior to procurement and delivery. The provision of the correct faceplates and fittings for use in specialized mounting requirements is the sole responsibility of the Contractor.
B. Receptacle (outlet) box for modular furniture:
   1. Provide receptacle (outlet) box for modular furniture as shown on Drawings. Receptacle box shall be provided to interface with modular systems furniture.
   2. Receptacle boxes shall be single gang unless specified otherwise on Drawings.
   3. Receptacle box shall be complete with extension box.

PART 3 - EXECUTION

3.1 RECEPTACLE (OUTLET) BOXES
A. Receptacle (outlet) box for modular furniture:
   1. Receptacle box shall be installed for all modular furniture stations as shown on the Drawings.
B. Receptacles shall be securely installed in accordance with the manufacturers installation sheets and furniture installation recommendations.
## EQUIPMENT SCHEDULE - SR

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END OF SECTION
SECTION 27 40 00
AUDIOVISUAL - GENERAL REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY
A. This Section provides supplemental information to Division 27 Specification Section Basic Communications Requirements.

B. Provide all labor, materials, equipment, tools and services required for the installation of the Audiovisual Systems.

1.2 RELATED SECTIONS
A. Division 27 Specification Section Common Work - Sleeves, Penetrations and Firestopping. Provide sleeves, penetrations, and firestopping as required to support the work of this Section.

B. Division 27 Specification Section Common Work – Hangers and Supports. Provide hangers and supports as required to support the work of this Section.

C. Division 27 Specification Section Communications – Horizontal Cabling. Provide sleeves, penetrations, and firestopping as required to support the work of this Section.

D. Division 27 Specification Section Communications – Faceplates and Connectors. Provide hangers and supports as required to support the work of this Section.

1.3 SUBMITTALS
A. Provide the following per the criteria set forth for Submittals in Division 27 Specification Section Basic Communications Requirements:
   1. Product Data
   2. Shop Drawings

1.4 RECORD DOCUMENTS
A. Provide Record Documents per the criteria set forth for Record Documents in Division 27 Specification Section Basic Communications Requirements.

1.5 OPERATION AND MAINTENANCE MANUALS
A. Provide Operation and Maintenance Manuals per the criteria set forth for Operation and Maintenance Manuals in Division 27 Specification Section Basic Communications Requirements.

PART 2 - MATERIALS

2.1 THIS SECTION NOT USED
PART 3 - EXECUTION

3.1 GENERAL

A. Work shall comply with the Governing Requirements as defined in Division 27 Specification Section Basic Communications Requirements. Governing Requirements of particular relevance to this Section include, but are not limited to:

1. IEEE C62.41: Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits
2. UL 1449: Transient Voltage Surge Suppressors

3.2 SOFTWARE IMPLEMENTATION

A. The Contractor shall provide all software implementation as required to provide a fully functional and operating system ready for the Owner’s use. Software implementation shall include but not be limited to programming, configuration, modification, integration of other systems, integration of exist systems, data entry and installation. Existing Audiovisual Systems shall be incorporated into new/expansion systems, as required.

3.3 HARDWARE CONFIGURATION

A. The Contractor shall provide all hardware configurations as required to provide a fully functional and operating system ready for the Owner’s use. Hardware configuration shall include but not limited to firmware configuration, data communication, system settings, power distribution and installation. Existing Audiovisual Systems shall be incorporated into new/expansion systems, as required.

3.4 INSTALLATION

A. Pathways: Prior to installation of Audiovisual cabling, Contractor shall verify conduit sizing and quantity for correctness. Deviations from design documents shall be documented and Contractor shall contact Engineer with notification of deviation.

B. Cabling:

1. Circuits shall be physically separated by metal raceway or by a minimum distance of six inches when metal raceway is not applicable. Circuit separation shall be based upon signal level:
   a. Audio circuits -20dBm or less – Microphone signal
   b. Audio circuits -20dBm thru +20dBm - Line level audio
   c. Audio circuits +20 or above – Loudspeaker signal
   d. Video circuits: 1 volt
   e. Computer data circuits: 1 volt
   f. Direct current power circuits: 1 – 24 volts

2. Cable pulls shall be conducted within the following requirements:
   a. Manufacturer’s guidelines for pulling tension and bend radii.
   b. Circuit separation.
   c. NEC conduit fill standards. The Contractor shall notify Engineer prior to cable installation when the conduits are found to be undersized.
   d. Any cable found to be faulty due to poor cable pull practices shall be removed and replaced at no additional cost to Owner.
3. Cable splicing shall not be considered a common installation practice. If necessary, splice cables only in junction boxes or racks. Shielded cables shall not be spliced; instead each end shall be terminated with an appropriate connector to maintain shield continuity. Any cable found to be faulty due to splicing shall be removed and replaced at no additional cost to Owner.

4. The Contractor shall dress all cables at both ends with:
   a. Black heat shrink where jacketing has been stripped away to expose the individual conductors
   b. Clear heat shrink around the exposed shield conductor (Coax excluded)
   c. Printed, adhesive labels with clear heat shrink over each label

5. Contractor shall make all terminations with rosin-core solder, crimp/compression type connectors or captive screw type mechanical connections. For captive screw type mechanical connection, use spade type or ferrule type crimp connections. Bare wire terminations are not acceptable.

C. Equipment:
1. Equipment shall be installed as indicated and specified, and in accordance with the manufacture’s recommendations, except where local codes or regulations take precedence.
2. Place equipment labels or other identification where the label or identification can be easily seen and read without difficulty.
3. Equipment shall be installed level, plumb, parallel, and perpendicular to building structures and to other building systems and components, except where otherwise indicated.
4. Equipment shall be securely fastened. Select fasteners and supports so that the load applied to any one fastener maintains a minimum load factor of five.
5. Equipment locations: Prior to installation of Audiovisual equipment, Contractor shall coordinate with other trades and subsequently verify all equipment locations that mount on walls or within ceilings. This shall include but not be limited to:
   a. Structural elements such as lighting devices, HVAC equipment, fire protection devices, and cable tray
   b. Structural support elements for ceiling mounted devices
   c. Backing Board for wall mounted devices
6. Prior to head-end equipment installation, contractor shall verify equipment rooms are free of airborne contaminants.
7. After head-end equipment installation, contractor shall protect equipment from any future construction work that could cause damage to equipment, i.e. masonry, wood, paint, plumbing, etc.
8. Prior to furniture work, Contractor shall coordinate with other trades and subsequently verify all equipment locations that mount within furniture,
9. Contractor shall coordinate with architect as to any equipment color and finish requirements.

D. Grounding:
1. Contractor shall follow accepted engineering practices when installing the Audiovisual grounding system. The Audiovisual grounding system installation shall conform to NEC. The Contractor shall be responsible for correcting any signal grounding problems within the Audiovisual system (not Division 16 grounds) including but not limited to electromagnetic/electrostatic hums, ground loop anomalies, and distortions.
2. A grounding buss bar shall be installed in each equipment rack. The copper buss bar shall be sized to accommodate all connections plus future expansion.
   a. An insulated copper conductor properly sized shall bond the equipment rack buss bar to the dedicated ground conductor provided by Division 27.
b. A “Star Type” grounding network shall be established within the equipment rack. All Audiovisual components shall be grounded to this bus bar. Ground all components according to the following methods:
   1) Equipment having a power cord without a grounding conductor connected to chassis: furnish and install 14 AWG grounding conductor from component’s metallic chassis to grounding bus bar within rack.
   2) Equipment having a power cord with grounding conductor connected to chassis: do not install an additional grounding conductor.
   3) Physically isolate all rack mounted equipment from racks with isolation washers.
3. Shielded audio signal cables shall have the shields terminated at one end only. The non-terminated shield conductor shall be trimmed to a length of 1/4 inch, folded back against the cable jacketing and covered with black heat shrink.
4. All ungrounded equipment, such as microphones, shall have the shielding terminated at both ends with only one end connected to ground.
5. All Video and Data shielded cables shall have the shielded conductors terminated on both ends.

E. Structural Installations
1. Structural support elements:
   a. Structural support elements are defined as those materials added to structure for the reinforcement of general construction methods to meet a designed minimum load factor of five. These include but are not limited to:
      1) Backing boards required for the support of Audiovisual equipment or cabling
      2) Strut supports hung from structural beams or concrete slab
   b. It is the Electrical Contractor’s responsibility to provide structural support elements for the Audiovisual equipment.
   c. The Contractor shall provide all Audiovisual mounting and rigging equipment that fasten to the structural support elements.
   d. All support elements and fastenings shall be able to support a minimum load factor of five times the total assembled weight.
   e. The Contractor shall be responsible for the complete and correct installation of all the Audiovisual equipment.
2. Hard Ceiling Loudspeaker Locations:
   a. Hard ceiling loudspeaker locations requiring trim rings, rough-in brackets loudspeaker back boxes shall be installed during conduit installation.
   b. The Contractor shall install the trim rings, rough-in brackets and back boxes for hard ceiling locations in a timely manner, not to conflict with scheduled work of other trades. In the event that this equipment is not installed in a timely manner, the Contractor shall be responsible for all retrofit work and materials to provide a full functioning speaker assembly.
   c. It is the Contractors responsibility to coordinate installation with other trades.

3.5 TESTING
A. Performance Standards
1. Audio
   a. Electrical Requirements
      1) Frequency response: 20 Hz - 20KHz at ±1.0 dB
      2) Total harmonic distortion + noise: 20 Hz - 20KHz at ±1.0 percent dB
      3) Signal to noise ratio with crosstalk: minimum 55dB at 20 Hz – 20 KHz
   b. Acoustical Requirements
      1) Sound pressure levels shall evenly cover the audience area without audible distortions, hums, noise, rattles or buzzes.
         a) Nominal program material: 85 dB at ±2.0 dB with a minimum of 10 dB above ambient noise.
b) Nominal speech material: 85 dB at ±2.0 dB with a minimum of 10 dB above ambient noise.
c) Maximum sound pressure level: 100 dB at ±2.0 dB
d) Contractor shall make final loudspeaker sound pressure level adjustments according to owner’s recommendations determined during acceptance testing.

2) Frequency Response:
   a) Speech reinforcement: uniform response from 125 Hz – 2 KHz at ±2 dB. Below 125Hz, roll off 6 dB/octave. Above 2 KHz, roll off 3 dB/octave.
   b) Program reinforcement: uniform response from 63Hz – 2.5 KHz ±2 dB. Below 63 Hz, roll off appropriate to loudspeaker specification. Above 2.5 KHz, roll off 3 dB/octave.

2. Video
   a. Electrical Requirements
      1) Signal strength: minimum 70 I.R.E. with 100 percent SMPTE white reference level.
      2) Signal to noise ratio: minimum 55dB at 0 Hz - 4.2 MHz
      3) Crosstalk: minimum 45dB at 0 Hz - 4.2 MHz
      4) Frequency response: ±0.5 dB at 0 Hz - 4.2 MHz
      5) Line and field tilt: 2 percent maximum
      6) Differential gain: 3 percent maximum
      7) Differential phase: 2 degrees maximum
      8) Sync: 50 µseconds maximum
   b. Optical
      1) The projection system including projection screen, projector and mirrors shall be securely installed. No physical movement or vibration in projection system shall be acceptable.
      2) Projector light levels: ±15 percent output in lumens of projector specifications
      3) Projector light coverage: ±20 percent uniform light coverage within all areas of projection screen.

B. Operational Testing
   1. Prior to system training and acceptance testing, the Contractor shall perform and document operational testing.
   2. Contractor shall assemble the following test equipment:
      a. Ground fault indicator
      b. Digital Multi-meter
      c. Load resistors:
         1) Microphone load: 150 ohm, shielded, terminating resistors
         2) Line load: 600 ohm, shielded, terminating resistors
         3) Loudspeaker load: varies, match impedance measurements within 10 percent
      d. Sine Wave Generator:
         1) Continuously variable from 20Hz – 20kHz with level accuracy of 0.5dBu
         2) Level Range: -35 dBu to 26 dBu.
         3) Total Harmonic Distortion: 0.01 percent
      e. Pink Noise Generator
         1) Noise frequency: 20Hz – 20kHz, 1/3 octave band filtered
         2) Level Range: -35 dBu to 26 dBu.
         3) Total Harmonic Distortion: 0.01 percent
      f. Sound level meter meeting ANSI S1.4 specifications
      g. Polarity tester
      h. Impedance meter: Accuracy, 1 ohm – 8000 ohms, ±10 percent, 20Hz – 20kHz
      i. Oscilloscope: minimum of 20 MHZ bandwidth
j. Real-time spectrum or fast fourier transform analyzer:
   1) Filters: ANSI compliant with 1/3 octave band filtering
   2) Frequency range: 20Hz to 22Khz
   3) Frequency accuracy: ± 0.5 dB, 20 Hz to 22kHz
   4) Level range: 25 dB to 140 dB
   5) Level accuracy: ± 0.1 dB
k. Distortion analyzer: THD minimum 0.02 percent with accuracy of 5 percent of reading.
l. Video generator: SMPTE color bar, multi-burst, and full white patterns
m. Light meter: measurements in foot-candles and lux. Accuracy: 3 percent.
n. Waveform monitor
   o. Vectorscope
3. Nominal test signals:
   a. Level
      1) Microphone level: -50dBu
      2) Unbalanced line level: -10dBV
      3) Balanced line level: +4dBu
   b. Frequency:
      1) Full-range frequency loudspeaker networks: 1000Hz sine wave
      2) Crossover loudspeaker networks: apply a sine wave with a frequency centered within
         the frequency band of the signal path under test.
4. Field Measurements:
   a. Prior to any connections being made to building power, Contractor shall use a ground
      fault indicator to verify the circuits provided have proper ground wiring. Notify Owner
      upon discovery of any faulty wiring. In no way is Contractor to perform any work on any
      faulty electrical wiring discovered.
   b. Contractor shall produce a checklist for the testing and documentation of all Audiovisual
      equipment. Each device shall be verified for proper operation.
   c. Contractor shall correct any defects upon discovery. Contractor shall notify and
      coordinate with other trades to ensure all defects (including those by other trades that
      affect the Audiovisual system) are corrected and put into working order.
   d. Impedance testing: Measure and document impedance level of each loudspeaker cable
      entering equipment rack.
      1) Full-range frequency networks: measure impedance at 1000Hz.
      2) Crossover networks: measure impedance at center frequency for frequency band of
         loudspeaker network under test.
5. Audio System Measurements
   a. The following procedures are the minimum requirements for this testing section. These
      procedures are guidelines only; refer to listed reference material for testing criteria.
      Manufacturer’s recommendations for operation and connectivity of specific test
      equipment shall be observed for all testing procedures. Perform all applicable procedures
      and document results.
   b. Hum and noise testing: verify system is free of any hums, noises, buzzes, oscillations, or
      any other anomalies contributing to poor system operation. Correct any defects upon
      discovery.
   c. System Gain Structure
      1) The system gain structure shall be configured in such a way as to maximize dynamic
         range and provide a uniform clipping level across the entire audio system.
         a) References:
               Glen Ballou, editor. (Focal Press, Boston, 2002).
            ii. John Murray, Sound System Gain Structure (ProSonic Solutions, Woodland
                Park, CO).
      2) Contractor shall incorporate signal attenuation and gain devices as necessary to
         achieve proper system gain structure.
3) Procedure:
   a) Set signal path gains to a minimum while still passing signal.
   b) Set signal path processing equipment except bandpass filters to bypass.
   c) Set signal path volume attenuators to minimum attenuation.
   d) Connect a signal generator to the input of the signal path under test. Set the signal
      generator to a nominal frequency and level for the signal path under test. Set the
      input gain stage of the signal path under test to a nominal operating level (0 dB
      VU or -18 dBFS).
   e) Connect an oscilloscope to the final output of the signal path under test. Terminate
      the output with a load resistor appropriate for the signal path under test.
   f) Adjust the signal generator level to a maximum level just below clipping as
      measured on the oscilloscope.
   g) Set all gain stages in the signal path to a maximum level just below clipping as
      measured on the oscilloscope.
   h) Perform this procedure for all signal paths in the audio system.

4) Documentation:
   a) Document the final level of the signal path under test as measured on the
      oscilloscope for the signal path’s final settings.
   b) Document the signal generator’s output level.

d. Amplifier Gain Structure
   1) The amplifier gain structure shall be configured in such a way as to provide full
      amplifier gain at a maximum system input signal level just before clipping.
      References:
         Glen Ballou, editor. (Focal Press, Boston, 2002).
      ii. John Murray, *Sound System Gain Structure* (ProSonic Solutions, Woodland
          Park, CO).
   2) Procedure:
      a) Set signal path processing equipment except bandpass filters to bypass.
      b) Set signal path volume attenuators to minimum attenuation.
      c) Set the amplifier input attenuator of signal path under test to maximum
         attenuation.
      d) Connect a pink noise generator to the input of the signal path under test. Set the
         signal generator to a maximum system signal level just before clipping for the
         signal path under test.
      e) Terminate the loudspeaker network to the amplifier output of the signal path under
         test.
      f) Position a sound pressure level meter measurement microphone on-axis with the
         loudspeaker under test.
      g) Adjust the amplifier input attenuation of the loudspeaker network under test until
         one of the following conditions is reached:
         i. Amplifier maximum output level: the point at which the amplifier output
            signal begins to clip. Increase the amplifier input attenuation to achieve an
            output level just below signal clipping.
         ii. Loudspeaker maximum sound pressure level: the point at which further
             decrease of input attenuation has negligible effect upon the loudspeaker’s
             sound pressure levels. Increase the amplifier input attenuation to achieve the
             loudspeaker’s maximum sound pressure level.
         iii. Acoustic maximum sound pressure level: the point at which the loudspeaker
             sound pressure level measures the specified maximum sound pressure level as
             defined in the performance standards.
   3) Documentation:
      a) Document the amplifier input attenuation settings for the signal path under test.
      b) Document the sound pressure level of the loudspeaker under test.
e. Signal to Noise
1) The signal to noise testing shall be conducted to determine the amount of noise present in the audio system referenced to a nominal operating input signal.
   a) References:
      ii. Dennis Bohn, RaneNote 145, Audio Specification (Rane Corporation, Mukileto, WA).

2) Procedure:
   a) Set signal path processing equipment except bandpass filters to bypass.
   b) Set signal path volume attenuators to minimum attenuation.
   c) Connect a signal generator to the input of the signal path under test. Set the signal generator to a nominal frequency and level for the signal path under test.
   d) Replace signal generator with load resistor appropriate for signal path under test.

3) Documentation:
   a) Document the level as measured on the volt meter with the signal generator connected to input of the signal path under test.
   b) Document the level as measured on the volt meter with a load resistor connected to input of the signal path under test.

f. Frequency Response
1) The frequency response testing shall be conducted to determine the bandwidth of the audio system.
   a) References:
      ii. Dennis Bohn, RaneNote 145, Audio Specification (Rane Corporation, Mukileto, WA).

2) Procedure:
   a) Set signal path processing equipment except bandpass filters to bypass.
   b) Set signal path volume attenuators to minimum attenuation.
   c) Connect a signal generator to the input of the signal path under test. Set the signal generator to a nominal frequency and level for the signal path under test.
   d) Connect a volt meter to the output of the signal path under test. Terminate the output with a load resistor appropriate for the signal path under test.
   e) Calibrate the volt meter to 0 volts.
   f) Sweep the signal generator frequency from 20Hz to 20kHz.
   g) Perform this procedure for all signal paths in the audio system.

3) Documentation:
   a) Document all frequencies that deviate from the performance standards.

g. Total Harmonic Distortion + Noise
1) The total harmonic distortion testing shall be conducted to determine the linearity of the audio system.
   a) References:
      ii. Dennis Bohn, RaneNote 145, Audio Specification (Rane Corporation, Mukileto, WA).

2) Procedure:
   a) Set signal path processing equipment except bandpass filters to bypass.
   b) Set signal path volume attenuators to minimum attenuation.
   c) Connect an oscilloscope to the output of the signal path under test. Terminate the output with a load resistor appropriate for signal path under test.
d) Connect a signal generator to the input of the signal path under test. Set the signal generator to a nominal frequency for the signal path under test. Set the signal generator to a maximum level just before clipping for the signal path under test as measured on the oscilloscope.

e) Remove the oscilloscope and connect a distortion analyzer to the output of the signal path under test.

f) Perform this procedure for all signal paths in the audio system.

3) Documentation:
   a) Document the distortion readings as measured on the distortion analyzer for each signal path.

6. Acoustic Measurements
   a. The following procedures are the minimum requirements for this testing section. These procedures are guidelines only; refer to listed reference material for testing criteria. Manufacturer’s recommendations for operation and connectivity of specific test equipment shall be observed for all testing procedures. Perform all applicable procedures and document results.

   b. Perform testing procedures as applicable for the audio system under test.

   c. Hum and noise testing: verify the system is free of any hums, noises, buzzes, oscillations, or any other anomalies contributing to poor system operation. Correct any defects upon discovery. Contractor shall notify and coordinate with other trades to suppress any structural vibrations and noises caused by the audio system.

   d. Polarity
      1) Polarity testing shall be conducted to determine the phase discrepancies within the sound system cabling.
         a) References:

         2) Procedure:
            a) Set signal path processing equipment except bandpass filters to bypass.
            b) Set signal path volume attenuators to minimum attenuation.
            c) Connect the polarity test equipment to the signal path input under test.
            d) Measure polarity on-axis to the loudspeaker under test.
            e) Correct any deficiencies upon discovery.
            f) Perform this procedure for all signal paths in audio system.

e. Delay
   1) Delay setting shall be configured to compensate for the differing arrival times of the initial sound sources versus the audio system.
      a) References:

      2) Procedure:
         a) Set signal path processing equipment except bandpass to bypass.
         b) Set signal path volume attenuators to minimum attenuation.
c) Set the loudspeaker delay times as follows:
   i. Speech reinforcement systems: set the delay to achieve loudspeaker arrival
time consistence with the speech source arrival time.
   ii. Performance reinforcement systems: set the delay to achieve loudspeaker
arrival time consistence with performance source arrival time.
   iii. Video reinforcement systems: set the delay to achieve loudspeaker arrival
time consistence with the synchronization of video imagery at a listening position
approximate to the center of the viewing area.

3) Documentation:
   a) Document the delay settings for all loudspeaker networks.

f. Loudspeaker Frequency Response
   1) The frequency response of the loudspeakers shall be configured utilizing the audio
system equalizers to provide an acoustic frequency response as defined within the
Performance Standards section.
      a) References:
            Ed., Glen Ballou, editor. (Focal Press, Boston, 2002).
         ii. John Murray, Sound System Equalization (ProSonic Solutions, Woodland
             Park, CO).
   2) Procedure:
      a) Set signal path processing equipment except bandpass filters and system
         equalization to bypass.
      b) Set signal path volume attenuators to minimum attenuation.
      c) Connect a pink noise generator to the input of the signal path under test. Set the
         pink noise generator to a nominal level for signal path under test.
      d) Position the measurement microphone at an optimal testing position for
         loudspeaker under test.
      e) Utilize a real-time spectrum or fast fourier transform analyzer to measure the
         frequency response of the loudspeaker under test.
      f) Frequency Response Settings:
         i. Loudspeaker bandpass frequencies: set the bandpass filters to achieve
            frequency response as specified in the performance standards.
         ii. Loudspeaker equalization: set equalization to achieve frequency response as
             specified in the performance standards.
      g) Perform this procedure for all loudspeaker networks in audio system.
   3) Documentation:
      a) Document the frequency response for all loudspeaker networks.

g. Microphone Frequency Response
   1) The frequency response of the microphones shall be configured utilizing audio system
equalizers to provide an acoustic frequency response as defined within the
Performance Standards section.
      a) References:
            Ed., Glen Ballou, editor. (Focal Press, Boston, 2002).
         ii. John Murray, Sound System Equalization (ProSonic Solutions, Woodland
             Park, CO).
   2) Procedure:
      a) Set signal path processing equipment except bandpass filters and system
         equalization to bypass.
      b) Set signal path volume attenuators to minimum attenuation.
      c) Connect a pink noise generator to the microphone input of the signal path under
         test. Set the pink noise generator to a nominal level for signal path under test.
      d) Position the measurement microphone at an optimal testing position for
         loudspeaker under test.
e) Utilize a real-time spectrum or fast fourier transform analyzer to measure the frequency response of the loudspeaker under test.

f) Frequency response settings:
   i. Microphone bandpass frequencies: set the bandpass filters to achieve frequency response as specified in the performance standards.
   ii. Microphone equalization: set equalization to achieve frequency response as specified in the performance standards.

g) Perform this procedure for all microphone signal paths in audio system.

3) Documentation:
   a) Document the frequency response for all loudspeaker networks under test.

h) Feedback
   1) The audio system shall be configured utilizing the audio system equalizers to provide the most gain before feedback.
      a) References:
      b) Procedure:
         a) Set signal path processing equipment except bandpass filters and system equalization to bypass.
         b) Set signal path volume attenuators to maximum attenuation.
         c) Connect a pink noise generator to a system input. Set the pink noise generator to a nominal level for signal path under test.
         d) Position the system microphone at a typical operator location.
         e) Utilizing a microphone signal splitter, connect the system microphone under test to both a frequency analyzer and the microphone input of the signal path under test.
         f) Utilize a real-time spectrum or fast fourier transform analyzer to measure the frequency response of the system microphone under test.
         g) Adjust signal path volume attenuators to increase the loudspeaker sound pressure levels until the audio system reaches feedback.
         h) Measure the feedback frequency.
         i) Mute the audio system.
         j) Frequency response settings:
            i. Set the system equalization to eliminate the feedback frequency.
            ii. Perform this procedure for the microphone signal path under test until multiple frequencies feedback simultaneously.
         k) Perform this procedure for all microphone signal paths in the audio system.

   i) Loudspeaker Coverage
      1) The audio system shall be configured to provide uniform sound pressure levels within the audience areas.
         a) References:
      2) Procedure:
         a) Connect a pink noise generator to a system input. Set the pink noise generator to a nominal level for the signal path under test.
         b) Utilize a sound pressure level meter to measure the uniformity of the loudspeaker coverage of the audience areas at listening heights.
         c) Correct any deficiencies in the loudspeaker coverage that deviate from that specified in the performance standards.
3) Documentation:
   a) Document deviations from that specified in the performance standards.

j. Reverberation
   1) Measure the reverberation response of the room under test.
      a) References:
   2) Procedure:
      a) Set signal path volume attenuators to minimum attenuation.
      b) Connect a pink noise generator to a system input. Set the pink noise generator to a nominal level for signal path under test.
      c) Position the measurement microphone within the center of the audience area.
      d) Energize system loudspeakers to the nominal sound pressure level as specified in the performance standards.
      e) Remove all signals from the loudspeakers.
      f) Utilize a real-time spectrum or fast fourier transform analyzer to measure the required time for all frequencies to fall below the ambient noise level.

3) Documentation:
   a) Document the reverberation time.
   b) Document the ambient noise level.

7. Video System Measurements
   a. The following procedures are the minimum requirements for this testing section. These procedures are guidelines only; refer to listed reference material for testing criteria. Manufacturer’s recommendations for operation and connectivity of specific test equipment shall be observed for all testing procedures. Perform all applicable procedures and document results.
   b. Test all video signal paths with field connection points, field cabling and video equipment in place.
      1) Multi-conductor cabling:
         a) Test all the conductors in the same manner as a single composite conductor.
         b) Document the worst performing conductor of the multi-conductor cable.
            Performance of the remaining conductors shall be assumed to exceed performance of documented conductor.
   c. Noise and distortion testing: During the following procedures, verify system is free of any visual noises, oscillations, ground loop distortion or any other anomalies contributing to poor system operation. Correct any defects upon discovery.
   d. Insertion Gain
      1) The insertion gain test shall be performed to verify the amplitude continuity of the video signal path.
         a) References:
         b) Connect a video generator to the input of the signal path under test.
         c) Apply the “SMTPE color bar” test pattern.
         d) Connect a waveform monitor to the output of the signal path under test.
         e) Perform this procedure for all signal paths in video system.

3) Documentation:
   a) Document the following as measured of the waveform monitor.
      i. White level.
      ii. Black levels.
      iii. Blanking levels.
      iv. Sync levels.
      v. Sync pulse.
e. Frequency Response
   1) The frequency response test shall be performed to verify the uniform amplitude
      response as a function of frequency.
      a) References:
         i. Tektronix, “Waveform Monitor Techniques”, The Basics, NTSC Video
            Measurement (Tektronix Inc., Richardson TX).
   2) Procedure:
      a) Connect a video generator to the input of the signal path under test.
      b) Apply the “multi-burst” test pattern.
      c) Connect a waveform monitor to the output of the signal path under test.
      d) Perform this procedure for all signal paths in the video system.
   3) Documentation:
      a) Document the amplitude level of each frequency burst packet.
   f. Optical
   1) The light measurements shall be taken to verify the projector light output for
      uniformity, brightness and contrast.
   2) Procedure:
      a) Connect a video generator to the input of the signal path under test.
      b) Apply the “full white” test pattern.
      c) Utilizing a light meter, measure light output of projector under test.
      d) Perform this procedure for all projectors in the video system.
   3) Documentation:
      a) Document the ambient light levels at center of projection screen.
      b) Document the projector light levels at center of projection screen.
      c) Document the projector light levels at corners of projection screen.

C. Acceptance Testing
   1. System acceptance testing shall not be conducted until all final “as-built” drawings, manuals
      and operational testing have been completed and the documentation has been submitted for
      Engineer’s review.
   2. Acceptance testing shall be conducted with Contractor, Engineer, and Owner in attendance.
   3. Contractor shall demonstrate that all components of the Audiovisual Systems are in proper
      working order and are in accordance with specifications.
   4. At time of acceptance testing, all items found to be outside of specification requirements;
      Owner requirements, code requirements or general installation practices shall be added as
      new items to the final Punch List. All items found outside of specification requirements shall
      be put into working order prior to final acceptance of system.
   5. The Contractor shall assemble an inventory of installed equipment. This inventory shall be
      compiled at time of acceptance testing and compared to equipment listed in contractual
      documents.
   6. Acceptance testing may be suspended by Engineer if Audiovisual Systems are not complete
      and operable, equipment failure occurs, or installation is not in accordance with
      specifications. Contractor shall be responsible for any cost incurred by Engineer for
      additional site visits required to complete acceptance testing.

END OF SECTION
PART 1 - GENERAL

1.1 SUMMARY
A. This Section defines the Audiovisual System requirements for Audiovisual Systems within Architectural Spaces.

1.2 RELATED SECTIONS
A. The requirements of Division 27 Specification Section Audiovisual General Requirements shall serve as the basis for the requirements of this Section, and are incorporated by reference into this Section.

1.3 SYSTEM DESCRIPTION
A. Audiovisual System for Digital Signage spaces (Gallery, Café, Passage, Break Room and Main Stairs): The Audiovisual Contractor shall verify conduit, electrical boxes and structural supports for future audiovisual equipment has been installed according to Construction Documents. Pre-wire is not required.

B. Audiovisual System in the Small Conference Rooms: The functionality of the Audiovisual System within this space is to include but not be limited to the reinforcement of the presenter’s spoken word and the reinforcement of audio / video program material. The Audiovisual System within this space shall include but not be limited to the following system(s):
   1. The Video System(s) shall provide reinforcement and distribution of live and program source material to audience members within this space. This system shall include but not be limited to the following:
      a. Video Display System: The Video Display System shall include but not be limited to a wall mounted flat panel display, video processing equipment capable of processing multiple inputs / outputs of differing formats, and source equipment.
   2. The Audio System(s) shall provide reinforcement and distribution of live and program source material to audience members within this space. This system shall include but not be limited to the following:
      a. Sound Reinforcement System: The Sound Reinforcement System shall include but not be limited to integrated video display loudspeakers to provide coverage, audio processing equipment capable of processing multiple inputs / outputs of differing signal levels and source equipment.
   3. The Control System shall provide a seamless control process to unify the Audiovisual System. This system shall consist of but not limited to a configurable control processor capable of multiple control protocols and a control interface panel with a static button arrangement. The Control System shall provide full operation of the Audiovisual System.
      a. The Contractor shall coordinate with the Owner and the Engineer for the Control System operation and functionality requirements. The Contractor shall schedule a minimum of (2) Two Control System design meetings in which the Owner and/or Engineer shall be in attendance. These meetings shall establish the basis of the Control System programming requirements. The Control System design meetings shall be scheduled in a time manner as to not delay the completion of the Audiovisual System. Items to coordinate shall include but not be limited to:
         1) Control interface panel operation and functionality
2) Control System synchronized operations of multiple devices including but not limited to:
   a) Video display operation:
      i. Upon power-on:
         (a) The video display shall power-on
         (b) The video display shall default to the display’s “first position” (coordinate with Owner to determine “first position” default requirements)
      ii. Upon power-off:
         (a) The display shall power-off
         (b) The source audio associated with the display shall be remove from the Sound Reinforcement System unless otherwise noted or directed by Owner
         (c) The associated source equipment shall stop/ pause (as applicable)
   b) Source equipment operation
      i. Upon source selection:
         (a) The video display shall select the appropriate input and the image adjustment feature shall sync the video display to the appropriate input resolution.
         (b) The Sound Reinforcement System shall route selected audio signal to appropriate reinforcement equipment.
   b. The Contractor shall demonstrate the Control System functionality to the Owner prior to acceptance testing for evaluation. Any modifications required by the Owner shall be incorporated into the Control System prior to Acceptance Testing.
4. The Transmission System shall include but not be limited to the following:
   a. Traditional cable based system: This system shall consist of but not be limited to coax cable, shielded twisted pair cable, unshielded twisted pair and interface plates. Cable shall be installed and terminated to the manufacturer’s recommendations.
   b. Category rated unshielded twisted pair cable based system: This system shall consist of but not be limited to Category 5e cable, transmitters, receivers, intermediate cabling from audiovisual equipment to transmitters / receivers and interface plates. Category cable shall be installed and terminated to the manufacturer’s recommendations. Refer to the following specification sections for further installation and testing requirements:
      1) Division 27 Specification Section Communications – Horizontal Cabling
      2) Division 27 Specification Section Communications – Testing
      3) Division 27 Specification Section Communications – Patch Cords
C. Audiovisual System in the Medium Conference Rooms: The functionality of the Audiovisual System within this space is to include but not be limited to the reinforcement of the presenter’s spoken word and the reinforcement of audio / video program material. The Audiovisual System within this space shall include but not be limited to the following system(s):
   1. The Video System(s) shall provide reinforcement and distribution of live and program source material to audience members within this space. This system shall include but not be limited to the following:
      a. Video Projection System: The Video Projection System shall include but not be limited to a permanently mounted projector, a manual projection screen, video processing equipment capable of processing multiple inputs / outputs of differing formats, and source equipment.
2. The Audio System(s) shall provide reinforcement and distribution of live and program source material to audience members within this space. This system shall include but not be limited to the following:
   a. Sound Reinforcement System: The Sound Reinforcement System shall include but not be limited to overhead loudspeakers spaced evenly throughout audience area to provide uniform coverage, audio processing equipment capable of processing multiple inputs / outputs of differing signal levels, microphone(s) and source equipment. This system shall have separate loudspeaker networks each capable of individual equalization and level control.
3. The Control System shall provide a seamless control process to unify the Audiovisual System. This system shall consist of but not limited to a configurable control processor capable of multiple control protocols and a control interface panel with a static button arrangement. The Control System shall provide full operation of the Audiovisual System.
   a. The Contractor shall coordinate with the Owner and the Engineer for the Control System operation and functionality requirements. The Contractor shall schedule a minimum of (2) Two Control System design meetings in which the Owner and/or Engineer shall be in attendance. These meetings shall establish the basis of the Control System programming requirements. The Control System design meetings shall be scheduled in a time manner as to not delay the completion of the Audiovisual System. Items to coordinate shall include but not be limited to:
      1) Control interface panel operation and functionality
      2) Control System synchronized operations of multiple devices including but not limited to:
         a) Projector operation:
            i. Upon power-on:
               (a) The projector shall power-on
               (b) The audio / video switcher shall default to the projector’s “first position” preset (coordinate with Owner to determine “first position” default requirements)
            ii. Upon power-off:
               (a) The projector shall power-off
               (b) The source audio associated with the projector shall be remove from the Sound Reinforcement System unless otherwise noted or directed by Owner
               (c) The associated source equipment shall stop/ pause (as applicable)
            iii. Upon video mute:
               (a) The projector shall remain on while removing light output
               (b) The source audio associated with the projector shall be remove from the Sound Reinforcement System unless otherwise noted or directed by Owner
               (c) The associated source equipment shall stop/ pause (as applicable)
         b) Source equipment operation
            i. Upon source selection:
               (a) The A/V switcher shall route the selected source signal to the appropriate reinforcement equipment.
               (b) The projector shall select the appropriate input and the image adjustment feature shall sync the projector to the appropriate input resolution.
               (c) The Sound Reinforcement System shall route selected audio signal to appropriate reinforcement equipment.
   b. The Contractor shall demonstrate the Control System functionality to the Owner prior to acceptance testing for evaluation. Any modifications required by the Owner shall be incorporated into the Control System prior to Acceptance Testing.
4. The Transmission System shall include but not be limited to the following:
   a. Traditional cable based system: This system shall consist of but not be limited to coax cable, shielded twisted pair cable, unshielded twisted pair and interface plates. Cable shall be installed and terminated to the manufacturer’s recommendations.
b. Category rated unshielded twisted pair cable based system: This system shall consist of but not be limited to Category 5e cable, transmitters, receivers, intermediate cabling from audiovisual equipment to transmitters / receivers and interface plates. Category cable shall be installed and terminated to the manufacturer’s recommendations. Refer to the following specification sections for further installation and testing requirements:

1) Division 27 Specification Section Communications – Horizontal Cabling
2) Division 27 Specification Section Communications – Testing
3) Division 27 Specification Section Communications – Patch Cords

5. Racking System
a. Wall Rack: A wall rack shall be provided to house the majority of the audiovisual equipment. The rack shall be a hinging type rack with a lockable front door. The Contractor shall provide a power distribution and thermal dissipation system within the rack.

D. Audiovisual System in the Large Conference Rooms: The functionality of the Audiovisual System within this space is to include but not be limited to the reinforcement of the presenter’s spoken word and the reinforcement of audio / video program material. The Audiovisual System within this space shall include but not be limited to the following system(s):

1. The Video System(s) shall provide reinforcement and distribution of live and program source material to audience members within this space. This system shall include but not be limited to the following:
   a. Video Projection System: The Video Projection System shall include but not be limited to a permanently mounted projector, a motorized recess projection screen, video processing equipment capable of processing multiple inputs / outputs of differing formats, and source equipment.

2. The Audio System(s) shall provide reinforcement and distribution of live and program source material to audience members within this space. This system shall include but not be limited to the following:
   a. Sound Reinforcement System: The Sound Reinforcement System shall include but not be limited to overhead loudspeakers spaced evenly throughout audience area to provide uniform coverage, audio processing equipment capable of processing multiple inputs / outputs of differing signal levels, microphone(s) and source equipment. This system shall have separate loudspeaker networks each capable of individual equalization and level control.

3. The Control System shall provide a seamless control process to unify the Audiovisual System. This system shall consist of but not limited to a configurable control processor capable of multiple control protocols and a wired touch sensitive type control interface panel. The Control System shall provide full operation of the Audiovisual System.
   a. The Contractor shall coordinate with the Owner and the Engineer for the Control System operation and functionality requirements. The Contractor shall schedule a minimum of (2) Two Control System design meetings in which the Owner and/or Engineer shall be in attendance. These meetings shall establish the basis of the Control System programming requirements. The Control System design meetings shall be scheduled in a time manner as to not delay the completion of the Audiovisual System. Items to coordinate shall include but not be limited to:
      1) Control interface panel operation and functionality
2) Control System synchronized operations of multiple devices including but not limited to:
   a) Projector operation:
      i. Upon power-on:
         (a) The projector shall power-on
         (b) The projection screen shall lower into position
         (c) The audio / video switcher shall default to the projector’s “first position” preset (coordinate with Owner to determine “first position” default requirements)
      ii. Upon power-off:
         (a) The projector shall power-off
         (b) The projection screen shall rise into stored position
         (c) The source audio associated with the projector shall be remove from the Sound Reinforcement System unless otherwise noted or directed by Owner
         (d) The associated source equipment shall stop/ pause (as applicable)
      iii. Upon video mute:
         (a) The projector shall remain on while removing light output
         (b) The projection screen shall rise into stored position
         (c) The source audio associated with the projector shall be remove from the Sound Reinforcement System unless otherwise noted or directed by Owner
         (d) The associated source equipment shall stop/ pause (as applicable)
   b) Source equipment operation
      i. Upon source selection:
         (a) The A/V switcher shall route the selected source signal to the appropriate reinforcement equipment.
         (b) The projector shall select the appropriate input and the image adjustment feature shall sync the projector to the appropriate input resolution.
         (c) The Sound Reinforcement System shall route selected audio signal to appropriate reinforcement equipment.
   3) Network control features:
      a) The control system shall be available over the network via a web server. The web based control page shall have all the same control features as that available at the physical control interface.
      b. The Contractor shall demonstrate the Control System functionality to the Owner prior to acceptance testing for evaluation. Any modifications required by the Owner shall be incorporated into the Control System prior to Acceptance Testing.

4. The Transmission System shall include but not be limited to the following:
   a. Traditional cable based system: This system shall consist of but not be limited to coax cable, shielded twisted pair cable, unshielded twisted pair and interface plates. Cable shall be installed and terminated to the manufacturer’s recommendations.
   b. Category rated unshielded twisted pair cable based system: This system shall consist of but not be limited to Category 5e cable, transmitters, receivers, intermediate cabling from audiovisual equipment to transmitters / receivers and interface plates. Category cable shall be installed and terminated to the manufacturer’s recommendations. Refer to the following specification sections for further installation and testing requirements:
      1) Division 27 Specification Section Communications – Horizontal Cabling
      2) Division 27 Specification Section Communications – Testing
      3) Division 27 Specification Section Communications – Patch Cords

5. Racking System
   a. Floor Standing Rack: A floor standing rack shall be provided to house the majority of the audiovisual equipment. The floor standing rack shall be a rolling type rack with a lockable front door. The Contractor shall provide non-conductive conduit bushing to isolate rack from conduit. The Contractor shall provide a power distribution and thermal dissipation system within the rack.
E. Audiovisual System in the Director’s Conference Room (A171H): The functionality of the Audiovisual System within this space is to include but not be limited to the reinforcement of the presenter’s spoken word and the reinforcement of audio/video program material. The Audiovisual System within this space shall include but not be limited to the following system(s):

1. The Video System(s) shall provide reinforcement and distribution of live and program source material to audience members within this space. This system shall include but not be limited to the following:
   a. Video Display System: The Video Display System shall include but not be limited to a wall mounted flat panel display, video processing equipment capable of processing multiple inputs/outputs of differing formats, and source equipment.

2. The Audio System(s) shall provide reinforcement and distribution of live and program source material to audience members within this space. This system shall include but not be limited to the following:
   a. Sound Reinforcement System: The Sound Reinforcement System shall include but not be limited to integrated video display loudspeakers to provide coverage, audio processing equipment capable of processing multiple inputs/outputs of differing signal levels and source equipment.

3. Video Conferencing System shall provide transmission of audiovisual information via standard network cabling to remote audiences at distant locations. This system shall consist of but not be limited to a video codec, camera(s), and microphone(s).

4. The Control System shall provide a seamless control process to unify the Audiovisual System. This system shall consist of but not be limited to a configurable control processor capable of multiple control protocols and a control interface panel with a static button arrangement. The Control System shall provide full operation of the Audiovisual System.
   a. The Contractor shall coordinate with the Owner and the Engineer for the Control System operation and functionality requirements. The Contractor shall schedule a minimum of (2) Two Control System design meetings in which the Owner and/or Engineer shall be in attendance. These meetings shall establish the basis of the Control System programming requirements. The Control System design meetings shall be scheduled in a time manner as to not delay the completion of the Audiovisual System. Items to coordinate shall include but not be limited to:
      1) Control interface panel operation and functionality
      2) Control System synchronized operations of multiple devices including but not limited to:
         a) Video display operation:
            i. Upon power-on:
               (a) The video display shall power-on
               (b) The video display shall default to the display’s “first position” (coordinate with Owner to determine “first position” default requirements)
            ii. Upon power-off:
               (a) The display shall power-off
               (b) The source audio associated with the display shall be remove from the Sound Reinforcement System unless otherwise noted or directed by Owner
               (c) The associated source equipment shall stop/pause (as applicable)
         b) Source equipment operation
            i. Upon source selection:
               (a) The video display shall select the appropriate input and the image adjustment feature shall sync the video display to the appropriate input resolution.
               (b) The Sound Reinforcement System shall route selected audio signal to appropriate reinforcement equipment.
   b. The Contractor shall demonstrate the Control System functionality to the Owner prior to acceptance testing for evaluation. Any modifications required by the Owner shall be incorporated into the Control System prior to Acceptance Testing.
5. The Transmission System shall include but not be limited to the following:
   a. Traditional cable based system: This system shall consist of but not be limited to coax cable, shielded twisted pair cable, unshielded twisted pair and interface plates. Cable shall be installed and terminated to the manufacturer’s recommendations.
   b. Category rated unshielded twisted pair cable based system: This system shall consist of but not be limited to Category 5e cable, transmitters, receivers, intermediate cabling from audiovisual equipment to transmitters / receivers and interface plates. Category cable shall be installed and terminated to the manufacturer’s recommendations. Refer to the following specification sections for further installation and testing requirements:
      1) Division 27 Specification Section Communications – Horizontal Cabling
      2) Division 27 Specification Section Communications – Testing
      3) Division 27 Specification Section Communications – Patch Cords

F. Audiovisual System in the Teaching Laboratory(s) and Working Computer Laboratory: The functionality of the Audiovisual System within this space is to include but not be limited to the reinforcement of the presenter’s spoken word and the reinforcement of audio / video program material. The Audiovisual System within this space shall include but not be limited to the following system(s):

1. The Video System(s) shall provide reinforcement and distribution of live and program source material to audience members within this space. This system shall include but not be limited to the following:
   a. Video Projection System: The Video Projection System shall include but not be limited to a permanently mounted projector, a manual projection screen, video processing equipment capable of processing multiple inputs / outputs of differing formats, and source equipment.

2. The Audio System(s) shall provide reinforcement and distribution of live and program source material to audience members within this space. This system shall include but not be limited to the following:
   a. Sound Reinforcement System: The Sound Reinforcement System shall include but not be limited to overhead loudspeakers spaced evenly throughout audience area to provide uniform coverage, audio processing equipment capable of processing multiple inputs / outputs of differing signal levels, microphone(s) and source equipment. This system shall have separate loudspeaker networks each capable of individual equalization and level control.
   b. Assistive Listening System: The Assistive Listening System shall provide sound reinforcement and distribution of live and program source equipment to individual listeners via an RF transmission to personal listening devices. This system shall include but not be limited to transmitters, receivers, antennas and headphones.

3. The Control System shall provide a seamless control process to unify the Audiovisual System. This system shall consist of but not limited to a configurable control processor capable of multiple control protocols and a control interface panel with a static button arrangement. The Control System shall provide full operation of the Audiovisual System.
   a. The Contractor shall coordinate with the Owner and the Engineer for the Control System operation and functionality requirements. The Contractor shall schedule a minimum of (2) Two Control System design meetings in which the Owner and/or Engineer shall be in attendance. These meetings shall establish the basis of the Control System programming requirements. The Control System design meetings shall be scheduled in a time manner as to not delay the completion of the Audiovisual System. Items to coordinate shall include but not be limited to:
      1) Control interface panel operation and functionality
2) Control System synchronized operations of multiple devices including but not limited to:
   a) Projector operation:
      i. Upon power-on:
         (a) The projector shall power-on
         (b) The audio/video switcher shall default to the projector’s “first position” preset (coordinate with Owner to determine “first position” default requirements)
      ii. Upon power-off:
         (a) The projector shall power-off
         (b) The source audio associated with the projector shall be remove from the Sound Reinforcement System unless otherwise noted or directed by Owner
         (c) The associated source equipment shall stop/pause (as applicable)
      iii. Upon video mute:
         (a) The projector shall remain on while removing light output
         (b) The source audio associated with the projector shall be remove from the Sound Reinforcement System unless otherwise noted or directed by Owner
         (c) The associated source equipment shall stop/pause (as applicable)
   b) Source equipment operation
      i. Upon source selection:
         (a) The A/V switcher shall route the selected source signal to the appropriate reinforcement equipment.
         (b) The projector shall select the appropriate input and the image adjustment feature shall sync the projector to the appropriate input resolution.
         (c) The Sound Reinforcement System shall route selected audio signal to appropriate reinforcement equipment.
   b. The Contractor shall demonstrate the Control System functionality to the Owner prior to acceptance testing for evaluation. Any modifications required by the Owner shall be incorporated into the Control System prior to Acceptance Testing.

4. The Transmission System shall include but not be limited to the following:
   a. Traditional cable based system: This system shall consist of but not be limited to coax cable, shielded twisted pair cable, unshielded twisted pair and interface plates. Cable shall be installed and terminated to the manufacturer’s recommendations.
   b. Category rated unshielded twisted pair cable based system: This system shall consist of but not be limited to Category 5e cable, transmitters, receivers, intermediate cabling from audiovisual equipment to transmitters/receivers and interface plates. Category cable shall be installed and terminated to the manufacturer’s recommendations. Refer to the following specification sections for further installation and testing requirements:
      1) Division 27 Specification Section Communications – Horizontal Cabling
      2) Division 27 Specification Section Communications – Testing
      3) Division 27 Specification Section Communications – Patch Cords

5. Racking System
   a. Wall Rack: A wall rack shall be provided to house the majority of the audiovisual equipment. The rack shall be a hinging type rack with a lockable front door. The Contractor shall provide a power distribution and thermal dissipation system within the rack.
G. Audiovisual System in the Teaching Computer Laboratory: The functionality of the Audiovisual System within this space is to include but not be limited to the reinforcement of the presenter’s spoken word and the reinforcement of audio / video program material. The Audiovisual System within this space shall include but not be limited to the following system(s):

1. The Video System(s) shall provide reinforcement and distribution of live and program source material to audience members within this space. This system shall include but not be limited to the following:
   a. Video Projection System: The Video Projection System shall include but not be limited to a permanently mounted projector, a manual projection screen, video processing equipment capable of processing multiple inputs / outputs of differing formats, and source equipment.

2. The Audio System(s) shall provide reinforcement and distribution of live and program source material to audience members within this space. This system shall include but not be limited to the following:
   a. Sound Reinforcement System: The Sound Reinforcement System shall include but not be limited to overhead loudspeakers spaced evenly throughout audience area to provide uniform coverage, audio processing equipment capable of processing multiple inputs / outputs of differing signal levels, microphone(s) and source equipment. This system shall have separate loudspeaker networks each capable of individual equalization and level control.
   b. Assistive Listening System: The Assistive Listening System shall provide sound reinforcement and distribution of live and program source equipment to individual listeners via an RF transmission to personal listening devices. This system shall include but not be limited to transmitters, receivers, antennas and headphones.

3. The Control System shall provide a seamless control process to unify the Audiovisual System. This system shall consist of but not limited to a configurable control processor capable of multiple control protocols and a control interface panel with a static button arrangement. The Control System shall provide full operation of the Audiovisual System.
   a. The Contractor shall coordinate with the Owner and the Engineer for the Control System operation and functionality requirements. The Contractor shall schedule a minimum of (2) Two Control System design meetings in which the Owner and/or Engineer shall be in attendance. These meetings shall establish the basis of the Control System programming requirements. The Control System design meetings shall be scheduled in a time manner as to not delay the completion of the Audiovisual System. Items to coordinate shall include but not be limited to:
      1) Control interface panel operation and functionality
      2) Control System synchronized operations of multiple devices including but not limited to:
         a) Projector operation:
            i. Upon power-on:
               (a) The projector shall power-on
               (b) The audio / video switcher shall default to the projector’s “first position” preset (coordinate with Owner to determine “first position” default requirements)
            ii. Upon power-off:
               (a) The projector shall power-off
               (b) The source audio associated with the projector shall be remove from the Sound Reinforcement System unless otherwise noted or directed by Owner
               (c) The associated source equipment shall stop/ pause (as applicable)
iii. Upon video mute:
   (a) The projector shall remain on while removing light output
   (b) The source audio associated with the projector shall be remove from the
       Sound Reinforcement System unless otherwise noted or directed by Owner
   (c) The associated source equipment shall stop/ pause (as applicable)

b) Source equipment operation
   i. Upon source selection:
      (a) The A/V switcher shall route the selected source signal to the appropriate
          reinforcement equipment.
      (b) The projector shall select the appropriate input and the image adjustment
          feature shall sync the projector to the appropriate input resolution.
      (c) The Sound Reinforcement System shall route selected audio signal to
          appropriate reinforcement equipment.

b. The Contractor shall demonstrate the Control System functionality to the Owner prior to
   acceptance testing for evaluation. Any modifications required by the Owner shall be
   incorporated into the Control System prior to Acceptance Testing.

4. The Transmission System shall include but not be limited to the following:
   a. Traditional cable based system: This system shall consist of but not be limited to coax
      cable, shielded twisted pair cable, unshielded twisted pair and interface plates. Cable
      shall be installed and terminated to the manufacturer’s recommendations.
   b. Category rated unshielded twisted pair cable based system: This system shall consist of
      but not be limited to Category 5e cable, transmitters, receivers, intermediate cabling from
      audiovisual equipment to transmitters / receivers and interface plates. Category cable
      shall be installed and terminated to the manufacturer’s recommendations. Refer to the
      following specification sections for further installation and testing requirements:
         1) Division 27 Specification Section Communications – Horizontal Cabling
         2) Division 27 Specification Section Communications – Testing
         3) Division 27 Specification Section Communications – Patch Cords

5. Racking System
   a. Smart Lectern: A smart lectern with an equipment rack shall be provided to house the
      rack mounted equipment. The smart lectern shall provide shelving for equipment and a
      work area for laptops or other items. Connection points into the Audiovisual System shall
      be provided for auxiliary equipment. The Control System Interface Panel shall be located
      within the smart lectern. A work light shall be located within the shelf area of the lectern.
      The smart lectern shall be equipped with lockable doors. The lectern shall be affix to the
      floor with a removable latching system.

H. Audiovisual System in the Colloquium/Break Room: The functionality of the Audiovisual
   System within this space is to include but not be limited to the reinforcement of the presenter’s
   spoken word and the reinforcement of audio / video program material. The Audiovisual System
   within this space shall include but not be limited to the following system(s):
   1. The Video System(s) shall provide reinforcement and distribution of live and program source
      material to audience members within this space. This system shall include but not be limited
      to the following:
         a. Video Projection System: The Video Projection System shall include but not be limited
            to a permanently mounted projector, a motorized recess projection screen, video
            processing equipment capable of processing multiple inputs / outputs of differing
            formats, and source equipment.
         b. Video Display System: The Video Display System shall include but not be limited to a
            wall mounted flat panel display, video processing equipment capable of processing
            multiple inputs / outputs of differing formats, and source equipment.
2. The Audio System(s) shall provide reinforcement and distribution of live and program source material to audience members within this space. This system shall include but not be limited to the following:
   a. Sound Reinforcement System: The Sound Reinforcement System shall include but not be limited to overhead loudspeakers spaced evenly throughout audience area to provide uniform coverage, audio processing equipment capable of processing multiple inputs / outputs of differing signal levels, microphone(s) and source equipment. This system shall have separate loudspeaker networks each capable of individual equalization and level control.

3. Video Conferencing System: The Audiovisual Contractor shall verify conduit, electrical boxes and structural supports for future videoconferencing equipment has been installed according to Construction Documents. Pre-wire is not required.

4. The Control System shall provide a seamless control process to unify the Audiovisual System. This system shall consist of but not limited to a configurable control processor capable of multiple control protocols and a wired touch sensitive type control interface panel. The Control System shall provide full operation of the Audiovisual System.
   a. The Contractor shall coordinate with the Owner and the Engineer for the Control System operation and functionality requirements. The Contractor shall schedule a minimum of (2) Two Control System design meetings in which the Owner and/or Engineer shall be in attendance. These meetings shall establish the basis of the Control System programming requirements. The Control System design meetings shall be scheduled in a time manner as to not delay the completion of the Audiovisual System. Items to coordinate shall include but not be limited to:
      1) Control interface panel operation and functionality
      2) Control System synchronized operations of multiple devices including but not limited to:
         a) Video display operation:
            i. Upon power-on:
               (a) The video display shall power-on
               (b) The audio / video switcher shall default to the display’s “first position” preset (coordinate with Owner to determine “first position” default requirements)
            ii. Upon power-off:
               (a) The display shall power-off
               (b) The source audio associated with the display shall be remove from the Sound Reinforcement System unless otherwise noted or directed by Owner
               (c) The associated source equipment shall stop/ pause (as applicable)
         b) Projector operation:
            i. Upon power-on:
               (a) The projector shall power-on
               (b) The projection screen shall lower into position
               (c) The audio / video switcher shall default to the projector’s “first position” preset (coordinate with Owner to determine “first position” default requirements)
            ii. Upon power-off:
               (a) The projector shall power-off
               (b) The projection screen shall rise into stored position
               (c) The source audio associated with the projector shall be remove from the Sound Reinforcement System unless otherwise noted or directed by Owner
               (d) The associated source equipment shall stop/ pause (as applicable)
iii. Upon video mute:
   (a) The projector shall remain on while removing light output
   (b) The projection screen shall rise into stored position
   (c) The source audio associated with the projector shall be removed from the
       Sound Reinforcement System unless otherwise noted or directed by Owner
   (d) The associated source equipment shall stop/pause (as applicable)

c) Source equipment operation
i. Upon source selection:
   (a) The A/V switcher shall route the selected source signal to the appropriate
       reinforcement equipment.
   (b) The projector shall select the appropriate input and the image adjustment
       feature shall sync the projector to the appropriate input resolution.
   (c) The Sound Reinforcement System shall route selected audio signal to
       appropriate reinforcement equipment.

3) Network control features:
a) The control system shall be available over the network via a web server. The web
   based control page shall have all the same control features as that available at the
   physical control interface.
b) The Contractor shall demonstrate the Control System functionality to the Owner prior to
   acceptance testing for evaluation. Any modifications required by the Owner shall be
   incorporated into the Control System prior to Acceptance Testing.

5. The Transmission System shall include but not be limited to the following:
a. Traditional cable based system: This system shall consist of but not be limited to coax
   cable, shielded twisted pair cable, unshielded twisted pair and interface plates. Cable
   shall be installed and terminated to the manufacturer’s recommendations.
b. Category rated unshielded twisted pair cable based system: This system shall consist of
   but not be limited to Category 5e cable, transmitters, receivers, intermediate cabling from
   audiovisual equipment to transmitters / receivers and interface plates. Category cable
   shall be installed and terminated to the manufacturer’s recommendations. Refer to the
   following specification sections for further installation and testing requirements:
   1) Division 27 Specification Section Communications – Horizontal Cabling
   2) Division 27 Specification Section Communications – Testing
   3) Division 27 Specification Section Communications – Patch Cords

6. Racking System
a. Floor Standing Rack: A floor standing rack shall be provided to house the majority of the
   audiovisual equipment. The floor standing rack shall be a rolling type rack with a
   lockable front door. The Contractor shall provide non-conductive conduit bushing to
   isolate rack from conduit. The Contractor shall provide a power distribution and thermal
   dissipation system within the rack.

I. Audiovisual System in the 200 Seat Auditorium: The functionality of the Audiovisual System
within this space is to include but not be limited to the reinforcement of the presenter’s spoken
word and the reinforcement of audio / video program material. The Audiovisual System within
this space shall include but not be limited to the following system(s):
1. The Video System(s) shall provide reinforcement and distribution of live and program source
material to audience members within this space. This system shall include but not be limited
to the following:
a. Video Projection System: The Video Projection System shall include but not be limited
to a permanently mounted projector, a motorized recess projection screen, video
processing equipment capable of processing multiple inputs / outputs of differing
formats, and source equipment.
2. The Audio System(s) shall provide reinforcement and distribution of live and program source material to audience members within this space. This system shall include but not be limited to the following:
   a. Sound Reinforcement System: The Sound Reinforcement System shall include but not be limited to overhead loudspeakers spaced evenly throughout audience area to provide uniform coverage of voice/audio reinforcement, wall loudspeakers adjacent to the front projection screens to provide program audio, audio processing equipment capable of processing multiple inputs / outputs of differing signal levels, microphone(s) and source equipment. This system shall have separate loudspeaker networks each capable of individual equalization and level control.
   b. Assistive Listening System: The Assistive Listening System shall provide sound reinforcement and distribution of live and program source equipment to individual listeners via an RF transmission to personal listening devices. This system shall include but not be limited to transmitters, receivers, antennas and headphones.

3. Future Video Conferencing/Distance Learning System shall provide transmission of audiovisual information via standard network cabling to remote audiences at distant locations. This system shall consist of but not be limited to a video codec, camera(s), microphone(s) and an audio processor for echo cancelling.

4. The Owner Provided Audiovisual Recording/Lecture Capture System shall provide audio / video recording of live and program material. This system shall consist of but not be limited to the ability to interface with the data network system for media streaming. The Recording/Lecture Capture System shall integrate with the Audiovisual System, to include the Room Combining System.

5. Room Combining System: The Room Combining System shall provide combining / separation of the Audiovisual System across multiple rooms. This system shall consist of but not be limited to special equipment / functionality programmed or configured within the Audio, Video and Control Systems to provide a full functional and operating system ready for Owners use.

6. The Control System shall provide a seamless control process to unify the Audiovisual System. This system shall consist of but not limited to a programmable control processor capable of multiple control protocols and a wired touch sensitive type control interface panel. The Control System shall provide full operation of the Audiovisual System, to include any applicable Lighting Control System (by others) and motorized window shades (by others).
   a. The Contractor shall coordinate with the Owner and the Engineer for the Control System operation and functionality requirements. The Contractor shall schedule a minimum of (2) Two Control System design meetings in which the Owner and/or Engineer shall be in attendance. These meetings shall establish the basis of the Control System programming requirements. The Control System design meetings shall be scheduled in a time manner as to not delay the completion of the Audiovisual System. Items to coordinate shall include but not be limited to:
      1) Control interface panel operation and functionality
      2) Control System synchronized operations of multiple devices including but not limited to:
         a) Audiovisual System operation:
            i. Upon power-on:
               (a) The power sequencer shall apply power to the audio / video processing equipment first, the amplifier equipment last, the control processors remain always on and source equipment with RF tuners remain always on.
               (b) The Sound Reinforcement System shall be ready for use and the room volume levels will default to 1/3 of maximum volume level
               (c) Pan-tilt-zoom camera(s) shall default to “first position” preset (coordinate with Owner to determine “first position” default requirements)
ii. Upon power-off:
   (a) The power sequencer shall remove power from the amplifier equipment first, the audio / video processing equipment last, the control processors remain always on and source equipment with RF tuners remain always on.

b) Projector operation:
i. Upon power-on:
   (a) The projector shall power-on
   (b) The projection screen shall lower into position
   (c) The audio / video switcher shall default to the projector’s “first position” preset (coordinate with Owner to determine “first position” default requirements)

ii. Upon power-off:
   (a) The projector shall power-off
   (b) The projection screen shall rise into stored position
   (c) The source audio associated with the projector shall be remove from the Sound Reinforcement System unless otherwise noted or directed by Owner
   (d) The associated source equipment shall stop/ pause (as applicable)

iii. Upon video mute:
   (a) The projector shall remain on while removing light output
   (b) The projection screen shall rise into stored position
   (c) The source audio associated with the projector shall be remove from the Sound Reinforcement System unless otherwise noted or directed by Owner
   (d) The associated source equipment shall stop/ pause (as applicable)

c) Source equipment operation
i. Upon source selection:
   (a) The A/V switcher shall route the selected source signal to the appropriate reinforcement equipment.
   (b) The projector shall select the appropriate input and the image adjustment feature shall sync the projector to the appropriate input resolution.
   (c) The Sound Reinforcement System shall route selected audio signal to appropriate reinforcement equipment.

3) Network control features:
a) The control system shall be available over the network via a web server. The web based control page shall have all the same control features as that available at the physical control interface.

b. The Contractor shall demonstrate the Control System functionality to the Owner prior to acceptance testing for evaluation. Any modifications required by the Owner shall be incorporated into the Control System prior to Acceptance Testing.

7. The Transmission System shall include but not be limited to the following:
a. Traditional cable based system: This system shall consist of but not be limited to coax cable, shielded twisted pair cable, unshielded twisted pair and interface plates. Cable shall be installed and terminated to the manufacturer’s recommendations.

b. Category rated unshielded twisted pair cable based system: This system shall consist of but not be limited to Category 5e cable, transmitters, receivers, intermediate cabling from audiovisual equipment to transmitters / receivers and interface plates. Category cable shall be installed and terminated to the manufacturer’s recommendations. Refer to the following specification sections for further installation and testing requirements:
   1) Division 27 Specification Section Communications – Horizontal Cabling
   2) Division 27 Specification Section Communications – Testing
   3) Division 27 Specification Section Communications – Patch Cords

8. Clicker Technology shall be owner provided, owner installed.
9. Racking System
   a. Smart Lectern: A smart lectern with an equipment rack shall be provided to house the rack mounted equipment. The smart lectern shall provide shelving for equipment and a work area for laptops or other items. Connection points into the Audiovisual System shall be provided for auxiliary equipment. The Control System Interface Panel shall be located within the smart lectern. A work light shall be located within the shelf area of the lectern. The smart lectern shall be equipped with lockable doors. The lectern shall be affixed to the floor with a removable latching system.
   b. Floor Standing Rack: A floor standing rack shall be provided to house the majority of the audiovisual equipment. The floor standing rack shall be a pivoting type rack with a lockable front door. The Contractor shall provide non-conductive conduit bushing to isolate rack from conduit. The Contractor shall provide a power distribution and thermal dissipation system within the rack.

J. Audiovisual System in the 60 Seat and 110 Seat Classroom(s): The functionality of the Audiovisual System within this space is to include but not be limited to the reinforcement of the presenter’s spoken word and the reinforcement of audio / video program material. The Audiovisual System within this space shall include but not be limited to the following system(s):
   1. The Video System(s) shall provide reinforcement and distribution of live and program source material to audience members within this space. This system shall include but not be limited to the following:
      a. Video Projection System: The Video Projection System shall include but not be limited to a permanently mounted projector, a motorized recess projection screen, video processing equipment capable of processing multiple inputs / outputs of differing formats, and source equipment.
   2. The Audio System(s) shall provide reinforcement and distribution of live and program source material to audience members within this space. This system shall include but not be limited to the following:
      a. Sound Reinforcement System: The Sound Reinforcement System shall include but not be limited to overhead loudspeakers spaced evenly throughout audience area to provide uniform coverage of voice/audio reinforcement, wall loudspeakers adjacent to the front projection screens to provide program audio, audio processing equipment capable of processing multiple inputs / outputs of differing signal levels, microphone(s) and source equipment. This system shall have separate loudspeaker networks each capable of individual equalization and level control.
      b. Assistive Listening System: The Assistive Listening System shall provide sound reinforcement and distribution of live and program source equipment to individual listeners via an RF transmission to personal listening devices. This system shall include but not be limited to transmitters, receivers, antennas and headphones.
   3. Future Video Conferencing/Distance Learning System shall provide transmission of audiovisual information via standard network cabling to remote audiences at distant locations. This system shall consist of but not be limited to a video codec, camera(s), microphone(s) and an audio processor for echo cancelling.
   4. The Owner Provided Audiovisual Recording/Lecture Capture System shall provide audio / video recording of live and program material. This system shall consist of but not be limited to the ability to interface with the data network system for media streaming. The Recording/Lecture Capture System shall integrate with the Audiovisual System, to include the Room Combining System.
   5. Room Combining System: The Room Combining System shall provide combining / separation of the Audiovisual System across multiple rooms. This system shall consist of but not be limited to special equipment / functionality programmed or configured within the Audio, Video and Control Systems to provide a full functional and operating system ready for Owners use.
6. The Control System shall provide a seamless control process to unify the Audiovisual System. This system shall consist of but not limited to a programmable control processor capable of multiple control protocols and a wired touch sensitive type control interface panel. The Control System shall provide full operation of the Audiovisual System, to include any applicable Lighting Control System (by others) and motorized window shades (by others).

   a. The Contractor shall coordinate with the Owner and the Engineer for the Control System operation and functionality requirements. The Contractor shall schedule a minimum of (2) Two Control System design meetings in which the Owner and/or Engineer shall be in attendance. These meetings shall establish the basis of the Control System programming requirements. The Control System design meetings shall be scheduled in a time manner as to not delay the completion of the Audiovisual System. Items to coordinate shall include but not be limited to:

1) Control interface panel operation and functionality
2) Control System synchronized operations of multiple devices including but not limited to:

   a) Audiovisual System operation:

      i. Upon power-on:
         (a) The power sequencer shall apply power to the audio / video processing equipment first, the amplifier equipment last, the control processors remain always on and source equipment with RF tuners remain always on.
         (b) The Sound Reinforcement System shall be ready for use and the room volume levels will default to 1/3 of maximum volume level
         (c) Pan-tilt-zoom camera(s) shall default to “first position” preset (coordinate with Owner to determine “first position” default requirements)

      ii. Upon power-off:
         (a) The power sequencer shall remove power from the amplifier equipment first, the audio / video processing equipment last, the control processors remain always on and source equipment with RF tuners remain always on.

   b) Projector operation:

      i. Upon power-on:
         (a) The projector shall power-on
         (b) The projection screen shall lower into position
         (c) The audio / video switcher shall default to the projector’s “first position” preset (coordinate with Owner to determine “first position” default requirements)

      ii. Upon power-off:
         (a) The projector shall power-off
         (b) The projection screen shall rise into stored position
         (c) The source audio associated with the projector shall be remove from the Sound Reinforcement System unless otherwise noted or directed by Owner
         (d) The associated source equipment shall stop/ pause (as applicable)

      iii. Upon video mute:
         (a) The projector shall remain on while removing light output
         (b) The projection screen shall rise into stored position
         (c) The source audio associated with the projector shall be remove from the Sound Reinforcement System unless otherwise noted or directed by Owner
         (d) The associated source equipment shall stop/ pause (as applicable)

   c) Source equipment operation

      i. Upon source selection:
         (a) The A/V switcher shall route the selected source signal to the appropriate reinforcement equipment.
         (b) The projector shall select the appropriate input and the image adjustment feature shall sync the projector to the appropriate input resolution.
(c) The Sound Reinforcement System shall route selected audio signal to appropriate reinforcement equipment.

3) Network control features:
   a) The control system shall be available over the network via a web server. The web based control page shall have all the same control features as that available at the physical control interface.
   b) The Contractor shall demonstrate the Control System functionality to the Owner prior to acceptance testing for evaluation. Any modifications required by the Owner shall be incorporated into the Control System prior to Acceptance Testing.

7. The Transmission System shall include but not be limited to the following:
   a. Traditional cable based system: This system shall consist of but not be limited to coax cable, shielded twisted pair cable, unshielded twisted pair and interface plates. Cable shall be installed and terminated to the manufacturer’s recommendations.
   b. Category rated unshielded twisted pair cable based system: This system shall consist of but not be limited to Category 5e cable, transmitters, receivers, intermediate cabling from audiovisual equipment to transmitters / receivers and interface plates. Category cable shall be installed and terminated to the manufacturer’s recommendations. Refer to the following specification sections for further installation and testing requirements:
      1) Division 27 Specification Section Communications – Horizontal Cabling
      2) Division 27 Specification Section Communications – Testing
      3) Division 27 Specification Section Communications – Patch Cords

8. Racking System
   a. Smart Lectern: A smart lectern with an equipment rack shall be provided to house the rack mounted equipment. The smart lectern shall provide shelving for equipment and a work area for laptops or other items. Connection points into the Audiovisual System shall be provided for auxiliary equipment. The Control System Interface Panel shall be located within the smart lectern. A work light shall be located within the shelf area of the lectern. The smart lectern shall be equipped with lockable doors. The lectern shall be affixed to the floor with a removable latching system.
   b. Floor Standing Rack: A floor standing rack shall be provided to house the majority of the audiovisual equipment. The floor standing rack shall be a pivoting type rack with a lockable front door. The Contractor shall provide non-conductive conduit bushing to isolate rack from conduit. The Contractor shall provide a power distribution and thermal dissipation system within the rack.

PART 2 - MATERIALS

2.1 GENERAL

A. Manufacturer: Unless otherwise indicated, equipment in this Section shall be the standard products of a manufacturer regularly engaged in the manufacture of such products. All components used in the system shall be commercial designs that comply with the Specifications. Each major component of equipment shall identify the manufacturer’s name, model and serial number. Items of the same classification shall be identical. This includes equipment, modules, parts, and components. The Engineer retains the right to reject products which reflect, in the Engineer’s opinion, sub-standard design practices, manufacturing procedures, support services, or warranty policies.

B. Part Numbers: Refer to the equipment schedule at the end of this Section for specific part numbers. Part numbers listed in the equipment schedule define the performance specifications for the parts and shall be per the most recent manufacturer’s cut/data specification sheets available at the time of bid. If no part number is provided, then any part meeting the requirements specified is acceptable.
C. Provide materials in quantities as required to provide a fully functional and operational Audiovisual System ready for Owner’s use.

D. Owner Provided Contractor Installed: Refer to the equipment schedule at the end of this Section for procurement requirements. Equipment identified with an “OFCI” shall be provided by Owner for the Contractor to install.

2.2 EQUIPMENT SPECIFICATION

A. This equipment shall as a minimum conform to the following specifications.

1. Assistive Listening System
   a. The Assistive Listening System shall utilize a RF Transmitter to distribute audio signal to Personal Listening Devices.
   b. The Transmitter shall be frequency agile and rack mountable.
   c. The Personal Listening Device shall have channel selection, volume control and be battery powered.

2. Audio Power Amplifier
   a. The audio power amplifier shall provide balanced inputs and voltage transformer outputs.
   b. The audio power amplifier shall have attenuation pads to provide level control.
   c. The audio power amplifiers shall be rack mountable.

3. Audiovisual Switcher
   a. The audiovisual switcher shall provide routing of multiple A/V inputs to a single output.
   b. The audiovisual switcher shall provide an interface to a control system utilizing data communication.

4. Audiovisual Matrix Switcher
   a. The audiovisual matrix switcher shall provide routing of multiple A/V inputs to multiple outputs.
   b. The audiovisual switcher shall provide an interface to a control system utilizing data communication.

5. Control Interface
   a. The control interface shall have static hard wired button.
   b. The control interface shall be software configurable to accommodate a variety of manufacturers’ equipment.

6. Touch Control Interface
   a. The control interface shall be a software programmable touch screen
   b. The control interface shall be custom programmed by the Contractor to provide a user friendly control interface for the control of the Audiovisual System. Contractor shall coordinate with Owner to determine Control System requirements.
   c. The control interface shall be capable of video and computer image reproduction.
   d. The control interface shall be incorporating the Annotative System the touch screen functionality.

7. Control Processor
   a. The control processor shall be software programmable.
   b. The control processor shall be custom programmed by the Contractor to control all aspect of the Audiovisual System. Contractor shall coordinate with Owner to determine control system requirements.
   c. The control processor shall utilize various communication protocols to control the Audiovisual System components.
   d. The control processor shall provide a web interface for remote system access and control.
   e. The control processor shall be rack mountable.

8. Digital Signal Processor
   a. The digital signal processor shall process multiple input audio signals of both microphone and line level formats.
   b. The digital signal processor shall be capable of routing, mixing, equalization, filtering, and signal level control.
c. The digital signal processor shall provide automatic mixing of audio signals with suppression of audio echo and noise.
d. The digital signal processor shall provide an interface to a control system utilizing data communication.
e. The digital signal processor shall be rack mountable.
9. Document Camera
   a. The document camera shall be a desktop type camera with a flexible base.
   b. The document camera shall provide an interface to a control system utilizing data communication.
10. Ceiling Document Camera
    a. The document camera shall be a ceiling mounted camera.
    b. The document camera shall provide an interface to a control system utilizing data communication.
11. DVD/VCR Player
    a. The DVD/VCR player shall be a multi-region combined unit.
    b. The DVD/VCR player shall provide an interface to a control system utilizing infrared communication.
    c. The DVD/VCR player shall be rack mountable.
12. Floor Standing Rack
    a. The floor standing rack shall have a back can that mounts against a structural wall.
    b. The floor standing rack shall have a pivoting rack enclosure for access to rear of rack.
13. Floor Standing Rack
    a. The floor standing rack shall be constructed of a wood looking material with front and rear lockable doors.
    b. The floor standing rack shall be a free standing rack with casters.
    c. The floor standing rack shall have a pivoting rack enclosure for access to rear of rack.
14. Interface Plate
    a. The interface plates unless noted otherwise shall be made of 1/8 inch brushed anodized aluminum with beveled edges, with 1/8 inch high enamel filled lettering.
    b. Coordinated finish requirements with Architect / Owner prior to procurement.
15. Loudspeaker
    a. Ceiling Loudspeaker:
       1) The loudspeaker shall be a passive transducer with a voltage transformer with variable tap selection.
       2) The loudspeaker shall be a ceiling mounted type loudspeaker with appropriate tile bridge, back box and grille.
    b. Wall Loudspeaker
       1) The loudspeaker shall be a passive transducer with a voltage transformer with variable tap selection.
       2) The loudspeaker shall be a wall mounted type loudspeaker with appropriate trim ring, back box and grille.
16. Projector
    a. The projector shall have the capability to reproduce multiple A/V inputs of varying formats.
    b. The projector shall provide image size adjustment and image focusing.
    c. The projector shall provide an interface to a control system utilizing data communication.
    d. The projector shall provide image inversion for ceiling mounting.
    e. The projector shall be positioned centered on the projection screen, centered within the minimum and maximum throw distance. Base throw distance calculations on the native aspect ratio of the projector, unless otherwise noted.
17. Projection Screens - Electric
    a. The projection screen shall be motorized and recessed ceiling mounted.
    b. The projector screen shall have adequate drop material to extend the bottom of the projection screen to a distance of 4 foot above the finished floor, unless otherwise noted.
c. The projection screen shall be a tab tension type screen.
d. The projection screens shall provide an interface to a control system utilizing contact closures.
e. The projection screen shall utilize a 120VAC/60Hz circuit provided by Division 16.

a. The projection screen shall be manual and recessed ceiling mounted.
b. The projector screen shall have adequate drop material to extend the bottom of the projection screen to a distance of 4 foot above the finished floor, unless otherwise noted.
c. The projection screen shall be a tab tension type screen.

19. Rack Accessories
a. Rack accessories shall be made of 11 gauge aluminum and finished in black powder coat.

20. Recording System
a. The recording system shall be a multi-channel digital-based recording software suite.
b. The recording system software shall operate on a computer with a keyboard and mouse.
c. The recording system computer shall utilize a multi-channel sound card for analog to digital conversion.

21. Smart Lectern
a. The smart lectern shall have an integrated equipment rack to house audiovisual rack mounted equipment.
b. The smart lectern shall have (2) adjustable shelves, (1) monitor mount, and (1) keyboard tray.
c. The smart lectern shall have (2) hinged lockable door and (1) removable, lockable door.
d. The smart lectern shall be a movable lectern with the capability to be affixed to the floor.
e. The Contractor to coordinate finish requirements with Architect.

22. Video Codec
a. The video codec shall transmit audio/video signal via Ethernet to receiving unit at remote end.
b. The video codec shall be compatible with most major video codec manufacturers.
c. The audiovisual switcher shall provide an interface to a control system utilizing data communication.
d. The video codec shall be rack mountable.

23. Video Display
a. The video display shall have the capability to reproduce multiple A/V inputs of varying formats.
b. The video display shall be an active matrix LCD type display.
c. The video display shall incorporate speakers for audio reproduction.
d. The video display shall provide an interface to a control system utilizing data communication.
e. The video display shall be wall mounted.

2.3 **WIRE AND CABLE**

A. This equipment shall as a minimum conform to the following specifications. Cable conductor and gauge requirements may vary depending on device requirements. Contractor to determine and utilize cables with proper conductor and gauge requirements to provide optimum operation of system devices. Use Plenum equivalent cable as required.

1. Communication Cable: This cable shall conform to Division 27 Specification Section - *Communication Horizontal Cabling*.
2. Composite Video: This cable distances less than 100 feet shall be a Shielded//Coaxial one 20 AWG solid conductor, 75 ohm.
3. Composite Video: This cable distances more than 100 feet shall be a Shielded//Coaxial one 18 AWG solid conductor, 75 ohm.
4. Contact Closure: This cable shall be an Unshielded Twisted Non-Pair, (2) 20 AWG stranded conductor.
5. **Control System Data**: This cable shall be a Shielded Twisted Pair, (2) 18 AWG stranded conductor and a Shielded Twisted Pair, (2) 18 AWG stranded conductor.

6. **Infrared**: This cable shall be a Shielded Twisted Pair, (2) 22 AWG stranded conductor.

7. **Line Audio**: This cable shall be a Shielded/Twisted/Pair, two 22 AWG stranded conductor.

8. **Loudspeaker Audio**: This cable shall be an Unshielded/Twisted/Pair, two 16 AWG stranded conductor.

9. **Microphone Audio**: This cable shall be a Shielded/Twisted/Pair, two 22 AWG stranded conductor.

10. **Power supply**: This cable shall be a Shielded Twisted Pair, Unshielded Twisted Non-Pair, (2) 18 AWG stranded conductor.

11. **Radio Frequency**: This cable shall be a Shielded Coaxial, (1) 20 AWG solid conductor, 50 ohm.

12. **RGBHV Video**: This cable shall be a Shielded/ (5 individual coaxial conductors), one 26 AWG stranded conductor, 75 ohm.

13. **RS-232 Data**: This cable cable shall be a Shielded/Twisted/Pair, two 24 AWG stranded conductor.

14. **RS-422 Data**: This cable shall be a Shielded Twisted Pair, (4) 24 AWG stranded conductor.

15. **RS-485 Data**: This cable shall be a Shielded/Twisted/Pair, four 24 AWG stranded conductor.

### 2.4 MANUFACTURER SUPPORT CONTRACT(S)

**A.** The Contractor shall provide any manufacturer backed maintenance, warranty and/or technical support contract necessary for the Contractor to configure, operate, service, repair and/or replace any component of the Audiovisual System. The contract shall be valid for the duration of the warranty period. The Contractor shall purchase the contract in the Owner’s name and provide documentation and renewal information to the Owner at acceptance testing.

### PART 3 - EXECUTION

#### 3.1 REFERENCES

**A.** The Contractor shall closely coordinate with the Owner to ensure that Owner provided equipment is procured, configured (as necessary), and installed (as necessary) with ample lead time prior to the Contractor’s use of the equipment.

**B.** Refer to Division 27 Specification Section *Audiovisual General Requirements* for execution requirements.
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SECTION 27 54 00  
CABLE TV DISTRIBUTION SYSTEM

PART 1 - GENERAL

1.1 SUMMARY
A. This Section defines the Cable TV Distribution Network System.

1.2 RELATED SECTIONS
A. Division 270010 – Basic Communications Requirements, is incorporated by reference into this Section.
B. Division 270020 – Contractor Qualifications, is incorporated by reference into this Section.
C. Division 270030 – Bidding, is incorporated by reference into this Section.
D. Division 270040 – Warranty, is incorporated by reference into this Section.
E. Division 270050 – Quality Assurance, is incorporated by reference into this Section.
F. Division 270526 – Grounding and Bonding as required to support the work of this Section.
G. Division 270533 – Electrical Conduit and Boxes as required to support the work of this Section.
H. Division 270536 – Electrical Cable Trays as required to support the work of this Section.
I. Division 271300 – Communications – Backbone Cabling
J. Division 271500 – Communications – Horizontal Cabling

1.3 REFERENCES
A. Federal Communications Commission (FCC)
B. National Television System Committee (NTSC)

1.4 SCOPE OF WORK
A. The Contractor shall furnish and install a complete broadband Cable TV distribution system. The scope of work shall consist of furnishing all labor, equipment, supplies and materials, tools, services and facilities and performing all operations necessary for the installation of a broadband Cable TV distribution system, in accordance with the specifications and the accompanying drawings.
B. The Cable TV distribution system shall consist of coaxial cables, fiber node, signal taps, splitters, distribution amplifiers, signal equalizers, power supplies, and ancillary equipment as required to satisfy the system requirements.
C. The work shall include, but is not limited to the following. Furnish and install:
   1. Optical fiber node (rack mount)
   2. Broadband distribution amplifiers with equalizers and attenuators
   3. Passive Cable TV equipment, including Splitters and Directional couplers/taps
   4. Coaxial cables, including 0.500 Hardline trunk and riser cable and RG-6 drop cables
   5. Cable TV outlets, including connectors and faceplates
   6. Cable connectors and adapters
   7. Grounding and bonding of installed equipment
   8. All ancillary materials necessary to provide a complete broadband Cable TV distribution system
D. University of Colorado at Boulder (UCB) Cable TV staff shall interconnect the Cable TV Distribution Network for the building to the campus-wide Cable TV System. UCB shall furnish and install the Cable TV connector on the Cable TV Trunk cable installed by the Contractor and make the connection to the existing system.

1.5 SUBMITTALS

A. Shop drawings for the Cable TV distribution system shall also include a system block diagram and wall layouts of Cable TV equipment located within the telecommunications rooms. The system block diagram drawing shall include:
   1. A complete distribution system diagram indicating calculated forward signal levels delivered at each component in the system at the lowest frequency (50 MHz) and highest frequency (750 MHz).
   2. Calculations of cable loss at the lowest frequency and highest frequency between components within the system, such as between distribution amplifiers and Cable TV taps and/or splitters.
   3. Calculated values for each of the taps or splitters, including calculated line levels input at the tap or splitter in dBmV and output values in dBmV.
   4. Calculated input signal levels to each Cable TV outlet in dBmV.

1.6 SYSTEM DESCRIPTION

A. GENERAL
   1. The system shall use industry standard, commercially available active and passive components and devices to distribute the RF signals to the outlet locations.
   2. The Cable TV distribution system shall be a bi-directional, 750 MHz broadband system with a bandwidth of 44 to 750 MHz for the forward path and a bandwidth of 5 to 40 MHz for the return path. The system shall support a minimum of 110 channels.
   3. The tilt of the Cable TV Distribution system shall not exceed 6 dB between the highest and lowest frequencies anywhere in the system.
   4. All components within the system shall have a characteristic impedance of 75 ohms.
   5. The system carrier-to-noise ratio (CNR) shall not be less than 48 dB.
   6. Hum modulation shall be a minimum of 59 dB below visual carrier levels.
   7. Composite triple-beat (CTB) shall be a minimum of 55 dB below forward visual carrier levels.
   8. Signal levels at each Cable TV outlet shall be between 5 dBmV and 10 dBmV for both the lowest and highest frequencies of the system.
   9. Aural television carriers shall be maintained at a level of 15 dB below visual carrier level.

B. SYSTEM ARCHITECTURE
   1. University of Colorado at Boulder (UCB) transports Cable TV broadband signals on the main campus over a hybrid fiber/coaxial network. Cable TV service for the Systems Biotechnology Building shall be transported over singlemode fiber optic cable only utilizing APC connectors. Signals shall originate from a communications room located within the Stadium building and be transported over existing fiber optic cable to the Fiber Hut located at Colorado Avenue and 30th Street. New singlemode fiber optic cable shall be installed by the telecommunications contractor from the Fiber Hut into the new building through an existing ductbank to Innovation Drive and a new ductbank installed into the building as part of the project. Fiber optic connectors on existing singlemode fiber will need to be replaced with APC connectors and re-tested as part of the outside plant communications infrastructure required to support the Cable TV system.
   2. Passive and active Cable TV equipment shall be installed within the Telecommunications Rooms to provide distribution of the RF signal from the broadband coaxial taps to the Cable TV drop cables.
C. CABLE TV DROP CABLES
1. Cable TV drop cables shall be capable of supporting a 750 MHz broadband signal.
2. Cable TV drop cables shall consist of RG-6 coaxial cables, unless otherwise noted. The Contractor shall install RG-11 coaxial cables on any long cable runs if required to support the required signal levels at outlets, as specified herein.
3. Install Cable TV drop cables in a star topology from the Telecommunications Room to each Cable TV outlet shown on the drawings.
4. Drop cables shall be routed through the cable tray and conduit telecommunications pathways to the outlets as shown on the drawings.
5. Include a minimum 5 foot service loop on all Cable TV drop cables within the Telecommunications Rooms to facilitate future moves, adds and changes.

D. CABLE TV OUTLETS
1. Furnish and install Cable TV outlets as shown on the drawings.
2. Cable TV outlets shall be used to terminate the coaxial drop cables routed from the Telecommunications Rooms and provide the interface to the end user’s consumer electronics equipment.
3. Cable TV outlets shall consist of single gang faceplates that fit standard electrical boxes with one (1) output female F-connector.
4. Cable TV outlets shall consist of either wall plates or wall taps. If signal levels are within acceptable levels at the outlets then wall plates are acceptable. If signal levels are higher than 10 dBmV then wall taps shall be used to attenuate the signal to acceptable levels.

PART 2 - MATERIALS

2.1 GENERAL
A. Manufacturer: Unless otherwise indicated, equipment in this Section shall be the standard products of a manufacturer regularly engaged in the manufacture of such products. All components used in the system shall be commercial grade products that comply with the specifications. Each major component of equipment shall identify the manufacturer’s name, model and serial number. Items of the same classification shall be identical. This includes equipment, modules, parts, and components. The Engineer retains the right to reject products which reflect, in the Engineer’s opinion, sub-standard design practices, manufacturing procedures, support services, or warranty policies.
1. Unless otherwise indicated, the equipment by the following manufacturers shall not be substituted. The Contractor shall provide the most current model and/or version of product available by listed manufacturer at time of procurement:
   a. Equipment: Motorola
   b. Cabling: CommScope
   c. Connectors: Corning/Gilbert

B. Part Numbers: Refer to the equipment schedule at the end of this Section for specific part numbers. Part numbers listed in the equipment schedule define the performance specifications for the parts and shall be per the most recent manufacturer’s cut/data specification sheets available at the time of bid. If no part number is provided, then any part meeting the requirements specified is acceptable.
C. Provide materials in quantities as required to provide a fully functional Cable TV Distribution System ready for Owner’s use.
2.2 EQUIPMENT SPECIFICATIONS

A. Cable TV Headend Fiber Node
   1. The unit shall accommodate 870 MHz 2-way operation with plug-in inter-stage EQ and Pad and shall have an integral optical power meter.
   2. The unit shall have plug-in accessories and support variable gain and tilt controls.
   3. ATX Networks QFRN 870A Headend Fiber Node

B. Cable TV Broadband Distribution Amplifier
   1. The broadband distribution amplifier shall be used as a launch amplifier in a coaxial distribution system fed from a coaxial broadband network.
   2. The unit shall be a two-way capable dual output amplifier offering high gain, high output levels, ergonomics, superior distortion performance, four duplex filter options, 16 dB return loss, and Bode equalization. A third output shall be user-configurable via splitter or directional coupler plug-in.
   3. The amplifier shall utilize 870 MHz Enhanced Gallium Arsenide (E-GaAs) power doubling technology.
   4. Bandwidth: 870 MHz
   5. Frequency Range: 47-860 MHz
   6. Broadband amplifiers shall be wall mountable units
   7. Motorola Starline BLE “Broadband Line Extender” for single output designs
   8. Motorola Starline MB “Mini-Bridger” series model for multiple output designs

C. Cable TV Signal Splitters
   1. The Cable TV distribution system shall use signal splitters, directional couplers, and isolation taps as required to meet the system performance requirements.
   2. Signal splitters shall be AC power-passing, two-way devices capable of operating within an RF passband of 1 GHz.
   3. Signal splitters shall be enclosed in die cast 360 aluminum alloy housings.
   4. Signal splitters shall be passive devices that employ a swivel center conductor mechanism and a rotatable faceplate to ensure that the units can be configured in a variety of input/output and RF/AC combinations.
   5. Signal splitters shall be capable of combining RF with AC power from the system power supplies to coaxial cable, and shall allow use of 60 and 90 volt powered systems. It shall be capable of being installed on coaxial cable and pass up to 15 amperes in each direction – a total of 20 amperes common, available with 2-way, 3-way, 4-way and 6-way output ports.

D. Cable TV Directional Couplers/Taps
   1. The Cable TV distribution system shall use signal splitters, directional couplers, and isolation taps as required to meet the system performance requirements.
   2. Directional couplers/taps shall offer improved return path performance for Cable TV Distribution systems.
   3. Directional couplers/taps shall be capable of offering a variety of plug-in, field configurable modules that allow greater flexibility in system design. These modules shall include cable equalizers, return path attenuators, and cable simulators for achieving the desired return path system performance. For any of the plug-in module options, the feederline shall remain unaffected due to the location of the plug-in within the circuitry. Only the drop signals shall be affected by the plug-in.
   4. Directional couplers/taps shall be capable of passing a maximum of 12 amperes continuous from input to output on the feeder. These taps shall provide optimal hum modulation performance at high currents and be capable of being used in both 60 and 90 volt systems.
   5. Directional couplers/taps shall provide feeder-line continuity when the faceplate is removed.
   6. Directional couplers/taps shall be constructed of a surface chromate conversion over a die-cast housing and faceplate made of 360-aluminum alloy.
7. Impedance on ports shall be 75 ohms.

E. Cable TV Outlets
   1. Furnish and install Cable TV outlets as shown on the drawings.
   2. Cable TV outlets shall be used to terminate the coaxial drop cables routed from the telecommunications rooms and provide the interface to the end user’s consumer electronics equipment.
   3. Cable TV outlets shall consist of single gang faceplates that fit standard electrical boxes with one (1) output female F-connector.
   4. Wall plates shall consist of female-to-female F-81 barrel F-connectors with hex nuts in single gang faceplates.
   5. Cable TV outlets shall as a minimum conform to the following specifications:
      a. Frequency range of 5-900 MHz.
      b. Impedance: 75 ohms
   6. Outlets shall be manufactured by Corning/Gilbert.

F. Cable TV Connectors
   1. Furnish and install all coaxial cable connectors required for proper termination of cables and interconnection to equipment.
   2. Connectors shall be compression style.
   3. Provide connectors that terminate 0.500 hardline coaxial trunk and riser cables and RG-6 and RG-11 coaxial drop cables.
   4. Connectors and adapters shall be high quality, providing excellent RF shielding to reduce RFI leaks into the Cable TV distribution system that can cause spurious carriers to fall in the cable spectrum.
   5. Cable TV connectors shall be manufactured by Corning/Gilbert.

G. Cable TV Drop Coaxial Cable
   1. Cable TV drop cables shall consist of RG-6 coaxial cables.
   2. RG-6 cable shall consist of an 18 AWG copper covered steel center conductor with a polyethylene foam dielectric.
   3. Cable shall have a quad shield consisting of an aluminum foil shield over the foam dielectric with a 60 percent braid shielding over the foil, plus another aluminum foil with a 40 percent aluminum braid.
   4. Cable shall be NEC CATVR riser rated cable.
   5. Nominal impedance shall be 75 ohms.
   6. Velocity of propagation shall be at least 82 percent.
   7. Cable attenuations at 68 degrees F shall not be greater than 1.50 dB/100 feet at 55 MHz and 5.62 dB/100 feet at 860 MHz.
   8. Cable shall be capable of supporting satellite, broadband video, video distribution and MATV applications.

PART 3 - EXECUTION

3.1 GENERAL
   A. Install all equipment in strict accordance with the manufacturer’s recommendations and in compliance with the requirements of the NEC, OSHA and the rules, regulations and requirements of the FCC.
   B. The installation shall comply with federal, city, county and state laws, ordinances, regulations, and codes applicable to the installation.
C. The locations of outlets and equipment panels as indicated on the drawings are approximately correct and are understood to be subject to such revision as may be found necessary or desirable at the time of installation. Contractor should have precise and definite locations accepted by the Owner and Engineer before proceeding with the installation.

D. The locations of outlets and equipment panels as indicated on the drawings are approximately correct and are understood to be subject to such revision as may be found necessary or desirable at the time of installation. Contractor should have precise and definite locations accepted by the Owner and Engineer before proceeding with the installation.

E. The Contractor shall ground all Cable TV equipment within the telecommunications rooms to the telecommunications grounding busbars.

F. CABLE TV PROOF OF PERFORMANCE TESTING

1. Proof of Performance testing shall be required to certify that the Cable TV Distribution system operates as designed and intended. Proof of Performance testing shall involve two steps
   a. Aligning and balancing the system.
   b. Testing the system and its components.

2. Aligning and balancing the system involves adjusting the gain or sensitivity of the system’s amplifiers to match the specified signal levels and impedance within the system. The system’s performance cannot be analyzed until aligning and balancing is complete.

3. Aligning and Balancing the System:
   a. Upon completing the installation of all system components in the Cable TV Distribution system, the Contractor shall align and balance the system.
   b. Contractor shall insert an RF modulated signal into the system at the input of the launch amplifier and adjust the output gain of the launch amplifier so that a 42 dBmV signal level is output into the Cable TV Distribution system at the highest frequency of the system. Subsequently, align and balance all amplifiers in the system at the high and low frequencies.
   c. Contractor shall adjust the signal input levels in the amplifiers by using adjustable attenuation controls and fixed attenuators to obtain a level that is determined to be optimal for input into the amplifiers.
   d. Contractor shall setup the system using unity gain between amplifiers. At each amplifier, the output signal level shall be set to 42 dBmV at the highest channel. Thus the gain from one amplifier output to the next amplifier output is 0 dB or a gain of one, thus unity gain.
   e. The gain at each amplifier shall be adjusted for unity gain using the variable automatic gain control (AGC) feature of the amplifiers.
   f. Equalize the system at each amplifier between the highest and lowest frequencies by adjusting the variable slope controls and/or installing plug-in equalizers if a large tilt is required to compensate for the signal losses within the drop cables.
   g. Contractor shall select an optimum output signal level from the amplifiers for the lowest frequency of the system and adjust the slope on the amplifiers to ensure that the tilt within the system between the highest and lowest frequencies does not exceed 6 dB. Each amplifier shall then be set to produce the same output level at the low frequency to establish unity gain at the low frequency of the system.

4. Test Equipment:
   a. The Contractor executing this work shall own and maintain all necessary equipment to properly install the system in accordance with recommendations set forth by the manufacturers of each item of system equipment.
   1) A Signal Level Meter (SLM) capable of measuring levels between 5 and 860 megahertz.
   2) A flat noise generator or sweep/marker generator capable of providing a calibrated output between 5 and 860 megahertz.
   3) A Cumulative Leakage Index (CLI) Meter and dipole antenna.
5. Test Procedure:
   a. Prior to testing the Cable TV system, the Contractor shall submit the intended testing
      procedures, explaining, in detail, the step-by-step actions and expected results to
demonstrate compliance with the requirements of the specification.

6. Cable TV System Testing:
   a. Upon completing the installation of all system components in the Cable TV Distribution
      system, and performing the aligning and balancing of the system, the Contractor shall
      perform the following acceptance tests:
         1) Signal level tests at the low, mid and high frequencies of the system.
         2) Cumulative Leakage Index (CLI) test.
   b. Signal Level Test:
      1) Using a Signal Level Meter (SLM) and modulator, measure the signal levels at each
         Cable TV outlet in dBmV.
      2) Contractor shall apply signals to input of modulator and tune modulator to low, mid
         and high frequencies of the system and measure the signal level at each Cable TV
         outlet at these frequencies.
      3) Contractor to measure the signal levels at each Cable TV outlet at the low frequency
         channel (i.e. channel 2 at 54 MHz), a mid-frequency channel (i.e. channel 37 at 300
         MHz) and the high frequency channel (i.e. channel 116 at 750 MHz) of the system.
      4) Contractor shall demonstrate that each outlet has a signal level between 3 dBmV and
         10 dBmV and that there is no more than 6 dB variation between the lowest and
         highest frequencies of the system (i.e. 5MHz and 750MHz).
      5) Contractor shall submit a hard copy printout of the signal level test results for each
         Cable TV drop as part of the test reports.
   c. Cumulative Leakage Index (CLI) Test:
      1) The CLI Test shall be conducted to verify the RF shielding integrity of the system. It
         demonstrates the quality of the connectorization of the coaxial cable and
         interconnection of system components.
      2) The CLI Test will measure the RF leakage of the system which can interfere with
         FCC and FAA regulated systems. Moreover, if the system does not have tight RF
         shielding, unwanted RF signals can ingress into the system and cause unacceptable
         system performance.
      3) Contractor shall perform cumulative leakage index testing after the system has been
         installed and is activated with an RF input signal.
      4) Using a CLI Leakage Meter and dipole antenna, the Contractor shall walk-test the
         system at a distance of 6 to 10 feet and measure for RF leakage. Record any leaks that
         have a signal level of 20 microvolts and fix any leaks that have a signal level over 50
         microvolts.
## EQUIPMENT SCHEDULE - CATV

<table>
<thead>
<tr>
<th>ID</th>
<th>DESCRIPTION</th>
<th>Manufacturer/Part Number</th>
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<tr>
<td>TV100</td>
<td>OPTICAL FIBER NODE</td>
<td>See Special Reqmt ATX QFRN 870A Optical Node</td>
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<tr>
<td>TV110</td>
<td>CABLE TV SPLITTERS</td>
<td>SSP-xN Starline</td>
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<tr>
<td>TV120</td>
<td>CABLE TV EQUALIZABLE TAPS</td>
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<td>TV310</td>
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<td>TV350</td>
<td>CATV TRUNK CABLE</td>
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END OF SECTION
PART 1 - GENERAL

1.1 SUMMARY
A. This Section provides supplemental information to the Division 27 Specification Section Basic Requirements.
B. Provide all labor, materials, equipment, tools and services required for the installation of the Security Systems.

1.2 RELATED SECTIONS
A. Division 27 Specification Section Common Work - Sleeves, Penetrations and Firestopping. Provide sleeves, penetrations, and firestopping as required to support the work of this Section.
B. Division 27 Specification Section Common Work – Hangers and Supports. Provide hangers and supports as required to support the work of this Section.

1.3 SUBMITTALS
A. Provide the following per the criteria set forth for Submittals in Division 27 Specification Section Basic Requirements:
   1. Product Data
   2. Shop Drawings

1.4 RECORD DOCUMENTS
A. Provide Record Documents per the criteria set forth for Record Documents in Division 27 Specification Section Basic Requirements.

1.5 OPERATION AND MAINTENANCE MANUALS
A. Provide Operation and Maintenance Manuals per the criteria set forth for Operation and Maintenance Manuals in Division 27 Specification Section Basic Requirements.

PART 2 - MATERIALS

2.1 THIS SECTION NOT USED

PART 3 - EXECUTION

3.1 GENERAL
A. Work shall comply with the Governing Requirements as defined in Division 27 Specification Section Basic Requirements. Governing Requirements of particular relevance to this Section include, but are not limited to:
   1. IEEE C62.41: Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits
   2. UL 1449: Transient Voltage Surge Suppressors
3.2 SOFTWARE IMPLEMENTATION
A. The Contractor shall provide all software implementation as required to provide a fully functional and operating system ready for the Owner’s use. Software implementation shall include but not be limited to programming, configuration, modification, integration of other systems, data entry and installation. Existing Security System databases (i.e. card holder databases, biometric templates and/or log files) shall be incorporated into new/expansion systems, as required.

3.3 HARDWARE CONFIGURATION
A. The Contractor shall provide all hardware configurations as required to provide a fully functional and operating system ready for the Owner’s use. Hardware configuration shall include but not be limited to firmware configuration, data communication, system settings, power distribution and installation. Existing Security Systems shall be incorporated into new/expansion systems, as required.

3.4 INSTALLATION
A. Pathways: Prior to the installation of Security Systems cabling, Contractor shall verify conduit sizing and quantity for correctness. Deviations from the design documents shall be documented and Contractor shall contact Engineer with notification of deviation.

B. Cabling:
1. Security Systems cabling that is not network-based (i.e. Category 5E, 6, etc.) shall maintain separation from other system cabling and shall route within dedicated Security System pathways.
2. Cable pulls shall be conducted within the following requirements:
   a. Manufacturer’s guidelines for pulling tension and bend radii.
   b. NEC conduit fill standards. Contractor shall notify Engineer prior to cable installation when conduits are found to be undersized.
   c. Any cable found to be faulty do to poor cable installation practices shall be removed and replace at no additional cost to Owner.
3. Cable splicing shall not be considered a common installation practice. If necessary, splice cables only in junction boxes or racks. Shielded cables shall not be spliced; instead each end shall be terminated with an appropriate connector to maintain shield continuity. Any cable found to be faulty due to splicing shall be removed and replaced at no additional cost to Owner.
4. The Contractor shall dress all cables at both ends with:
   a. Black heat shrink where jacketing has been stripped away to expose individual conductors
   b. Clear heat shrink where shields have been exposed (Coax excluded)
   c. Printed, adhesive labels with clear heat shrink over each label
5. Contractor shall make all terminations with rosin-core solder, crimp/compression type connectors or captive screw type mechanical connections. For captive screw type mechanical connection, use spade type or ferrules type crimp terminations. Bare wire terminations are not acceptable.

C. Equipment:
1. Equipment shall be installed as indicated and specified, and in accordance with the manufacture’s recommendations, except where local codes or regulations take precedence.
2. Place equipment labels or other identification where the label or identification can be easily seen and read without difficulty.
3. Equipment shall be installed level, plumb, parallel, and perpendicular to building structures and to other building systems and components, except where otherwise indicated.
4. Equipment shall be securely fastened. Select fasteners and supports so that the load applied to any one fastener maintains a minimum load factor of five.

5. Equipment locations: Prior to installation of Security System equipment, Contractor shall coordinate with other trades and subsequently verify all equipment locations that mount on walls or within ceilings. This shall include but not be limited to:
   a. Structural elements such as lighting devices, HVAC equipment, fire protection devices, and cable tray
   b. Structural support elements for ceiling mounted devices
   c. Backing Board for wall mounted devices

6. Prior to head-end equipment installation, contractor shall verify equipment rooms are and will remain free of airborne contaminants.

7. After head-end equipment installation, contractor shall protect equipment from any future construction work that could cause damage to equipment, i.e. masonry, wood, paint, plumbing, etc.

8. Prior to furniture work, Contractor shall coordinate with other trades and subsequently verify all equipment locations that mount within furniture.

9. Contractor shall coordinate with architect as to any equipment color and finish requirements.

10. Any equipment exposed to tampering or indicated as tamper or vandal proof shall be installed with tamper/vandal proof enclosures and secured using pin-head Torx fasteners suitable for the material and load requirements.

D. Grounding and Surge Protection:
   1. The Contractor shall follow accepted engineering practices when installing the Security Systems grounding system. The security grounding system installation shall conform to NEC standards. The contractor shall be responsible for correcting any grounding problems within the Security System including but not limited to electromagnetic/electrostatic interference, ground loops anomalies, and distortions.

   2. All devices installed to the exterior of structure shall be protected from surge voltages with surge suppression devices. Install surge suppression devices in strict accordance with the manufacturer requirements.

   3. All solenoid or coil driven devices (i.e. door strikes, pin bolt locks, large relays, gate operators and magnetic locks) shall be installed with metal oxide varistors for surge suppression.

E. Structural Installations
   1. Structural support elements are defined as those materials added to structure for the reinforcement of general construction methods to meet a designed minimum load factor of five. These include but are not limited to:
      a. Backing boards required for the support of Security System equipment and cabling
      b. Strut supports hung from structural beams or concrete slab
   2. It is the Electrical Contractor’s responsibility to provide structural support elements for the Security Systems equipment.

   3. The Contractor is to provide all Security Systems mounting and rigging equipment that fasten to the structural support elements.

   4. All support elements and fastenings shall be able to support a minimum load factor of five times the total assembled weight of the Security System equipment.

   5. The Contractor shall be responsible for the complete and correct installation of all Security Systems equipment.

3.5 TESTING

A. Operational Testing

   1. Prior to system training and acceptance testing, the Contractor shall perform and document operational testing.
a. Video Surveillance Systems
   1) Contractor shall assemble the following test equipment:
      a) Ground Fault Indicator
      b) Digital Multi-meter
      c) Video Volt Reading Meter
   2) Prior to any connections being made to building power, Contractor shall use a ground fault indicator to test that the circuits are properly grounded. If grounding is found to be faulty, the contractor shall notify the Electrical Contractor. Connections shall not be made to building power until proper grounding is demonstrated.
   3) Contractor shall produce a checklist for testing and documentation of all Video Surveillance Systems equipment. Each device shall be verified for proper operation at monitoring stations and camera locations. Devices under test shall consist of, but shall not be limited to: fixed cameras, camera power supplies, heating/cooling elements, video recording devices, monitoring devices and control system operation.
   4) Contractor shall utilize the video volt reading meter to measure and document the following I.R.E. levels of each analog camera:
      a) Sync Pulse
      b) Luminance
      c) Amplitude
      d) Color Burst
   5) Contractor shall correct any defective devise upon discovery. Contractor shall notify and coordinate with other trades to ensure faulty devices are put into working order.
   6) Contractor shall test and document all data transmissions for proper operation and correct any defect upon discovery.
   7) Contractor shall conduct operational testing, in accordance with the manufacturer’s approved test recommendations.

b. Access Control System
   1) Contractor shall assemble the following test equipment:
      a) Ground fault indicator
      b) Digital Multi-meter
   2) Prior to any connections being made to building power, Contractor shall use a ground fault indicator to verify the circuits are properly grounded wiring. If grounding is found to be faulty, the contractor shall notify the electrical contractor. Connections shall not be made to building power until proper grounding is demonstrated.
   3) The Contractor shall produce a checklist for testing and documentation of all Access Control System equipment. Each device shall be verified for proper operation at the monitoring stations and the door locations. Devices under test shall consist of, but not be limited to card readers, locking mechanisms, door position switches, request to exit devices, auto operators, handicap paddles, crash bars with switches, and overhead door operators.
   4) The Contractor shall correct any defective device upon discovery. The Contractor shall notify and coordinate with other trades as necessary to ensure faulty devices are put into working order.
   5) The Contractor shall test and document all “end of line resistance” values in all states of operation, where applicable. Correct any defect upon discovery.
   6) The Contractor shall test and document all data transmissions for proper operation. Correct any defect upon discovery.
   7) The Contractor shall conduct operational testing, in accordance with manufacturer approved test recommendations.
B. Acceptance Testing

1. System acceptance testing shall not be conducted until all final “as-built” drawings, manuals and operational testing have been completed and the documentation has been submitted for Engineer’s review.

2. Acceptance testing shall be conducted with Contractor, Engineer, and Owner in attendance.

3. Contractor shall demonstrate that all components of the Security System are in proper working order and are in accordance with specifications.

4. At time of acceptance testing, all items found to be outside of specification requirements; Owner requirements, code requirements or general installation practices shall be added as new items to the final Punch List. All items found outside of specification requirements shall be put into working order prior to final acceptance of system.

5. The Contractor shall assemble an inventory of installed equipment. This inventory shall be complied at time of acceptance testing and compared to equipment listed in contractual documents.

6. Acceptance testing may be suspended by Engineer if Security System are not complete and operable, equipment failure occurs, or installation is not in accordance with specifications. Contractor shall be responsible for any cost incurred by Engineer for additional site visits required to complete acceptance testing.

END OF SECTION
PART 1 - GENERAL

1.1 SUMMARY
A. This Section defines the Security System requirement for the Video Surveillance System.

1.2 RELATED SECTIONS
1. The requirements of Division 27 Specification Section Security - General Requirements shall serve as the basis for the requirements of this Section, and are incorporated by reference into this Section.

1.3 SYSTEM DESCRIPTION
A. The Video Surveillance System shall interface with other systems within the facility. Systems shall interface through hardware connectivity including but not limited to network / serial communication, contact closure and voltage / ground reference. The Video Surveillance System Contractor shall closely coordinate with other trades to ensure a fully functional, operating and integrated system ready for the Owner’s use. The Video Surveillance System shall interface with the following systems:
   1. Access Control System: Provide video monitoring for areas of access control alarms.

B. The primary function of the Video Surveillance System is to monitor / record events within specified areas of the facility. The Video Surveillance System shall include but not be limited to recording / camera processing equipment, camera equipment, communication equipment, a monitoring station(s), power supplies and any necessary cabling to provide a fully functional and operating system ready for the Owner’s use.
   1. The new Video Surveillance System recording equipment shall reside locally within this facility.
   2. The new Video Surveillance System shall record events within specified areas of the facility. The Owner shall interconnect the system to UCB’s Security network, which is a VLAN on the campus’ ITS network, through an IP port on a network switch within the new building. Digitized video signals of both real-time and recorded events shall be transported over the network and viewed on existing workstations that have been configured with Video Surveillance software. This includes CU Police Dispatch.
      a. The Contractor shall coordinate with the Owner to establish the security parameters to limit system accessibility to only authorized personnel. The Contractor shall also coordinate with the Owner to ensure all necessary network communications to locations outside of this facility are established.
   3. The Contractor shall provide video transmission via a Closed Circuit coaxial based cabling system.
      1) Structured Cabling: Structured cabling required for the direct operation of the Video Surveillance System shall be provided by the Communication Contractor. Structured cabling shall include but not limited to fiber optic and copper cabling used for data transmission.
      2) Coaxial Cabling: Coaxial cabling required for the direct operation of the Video Surveillance System shall be provided by the Security Contractor.
      3) Data Communications Equipment: Data communications equipment required for the direct operation of the Data Network System shall be provided by the Owner. Data communication equipment shall include but not limited to repeaters, switches with power-over-Ethernet and routers.
a) The Contractor shall coordinate with the Owner to ensure all Data Network System requirements have been provided, this is to include but not limited to patch panel configuration, switch/router allocation, IP addressing and network security.

4) Data Termination Equipment: Data termination equipment that reside outside of the Owners Data Network but is required for the direct operation of the Video Surveillance System shall be provided by the Contractor. Data termination equipment shall include but not limited to switches/routers, protocol converters, computers, network interface cards, network modules, serial servers and/or patch cabling.

a) Network termination equipment that the Video Surveillance System recording application(s) is to be installed upon shall be provided by the Contractor. This shall include but not limited to computers and data servers.

4. The Video Surveillance System shall operate within the parameters set forth below:
   a. The Video Surveillance System shall provide viewing of real-time and recorded events.
   b. The Video Surveillance System shall have emergency power backup capabilities in the event of power outage.
   c. Recording requirements: the Contractor shall coordination recording requirements with the Owner. Minimum recording requirements shall include but not be limited to:
      1) Video images shall be recorded at variable resolutions and frame rates
      2) Recorder shall provide audio/video recording.
      3) Recorded information shall be stored for a minimum of 30 days. Contractor to verify estimated storage capacity of video recorder. Storage time shall be calculated by highest available resolution at 15 frames per second at 50 percent recording based on motion detention. Refer to drawings for camera quantities.
      4) Event recording shall record at maximum resolution and frame rate for best image quality possible. Event recording shall include but not be limited to motion detection, contact closure events and analytical events.
      5) Event recording shall register within a log.
      6) Recorded information shall be transferable to long term storage.
   d. Monitoring requirements: the Contractor shall coordination monitoring requirements with the Owner. Minimum recording requirements shall include but not be limited to:
      1) Monitoring shall be provided remote of the recording equipment via the Data Network System.
      2) Monitoring stations shall display multiple cameras on a single video display.
      3) Monitoring stations shall provide customizable camera arrangements.
      4) Events shall be identified on the video display
   e. Control requirements:
      1) Camera selection and view controls shall be available via the monitoring station software user interface.
      2) Pan-tilt-zoom camera control shall be available via the monitoring station software user interface.
   f. The Video Surveillance System Monitoring Station(s) shall be located within an Owner specified location. The Monitoring Station shall consist of but not be limited to a computer(s), LCD monitor(s), and Monitoring Software. All components necessary for a fully functional and operational Monitoring Station shall be provided by the Owner.
PART 2 - MATERIALS

2.1 GENERAL

A. Manufacturer: Unless otherwise indicated, equipment in this Section shall be the standard products of a manufacturer regularly engaged in the manufacture of such products. All components used in the system shall be commercial designs that comply with the Specifications. Each major component of equipment shall identify the manufacturer’s name, model and serial number. Items of the same classification shall be identical. This includes equipment, modules, parts, and components. The Engineer retains the right to reject products which reflect, in the Engineer’s opinion, sub-standard design practices, manufacturing procedures, support services, or warranty policies.

1. Unless otherwise indicated, the equipment by the following manufacturers shall not be substituted. The Contractor shall provide the most current model and/or version of product available by listed manufacturer at time of procurement:
   a. American Dynamics
   b. Panasonic

B. Part Numbers: Refer to the equipment schedule at the end of this Section and/or within drawings for specific part numbers. Part numbers listed in the equipment schedule define the performance specifications for the parts and shall be per the most recent manufacturer’s cut/data specification sheets available at the time of bid. If no part number is provided, then any part meeting the requirements specified is acceptable.

C. Provide materials in quantities as required to provide a fully functional and Video Surveillance System ready for Owner’s use.

D. Owner Provided Contractor Installed: Refer to the equipment schedule at the end of this Section for procurement requirements. Equipment identified with an “OFCI” shall be provided by Owner for the Contractor to install.

2.2 EQUIPMENT SPECIFICATIONS

A. This equipment shall as a minimum conform to the following specifications:

1. Cameras
   a. Fixed Camera
      1) The camera shall be an analog based camera.
      2) The installation method for the camera shall include but not be limited to:
         a) The cameras installed within drop tile ceilings and shall include appropriate mounting hardware and shall be affixed to structure with hanger wire.
         b) The cameras installed onto walls or hard lid ceilings shall include appropriate mounting hardware and shall mount onto a standard electrical box.
         c) All exterior installed cameras shall include:
            i. Appropriate mounting hardware
            ii. Environmental protection including, but not limited to: environmental camera enclosures, heater/cooling elements, watertight cable pathways, watertight faceplates, watertight sealant and caulk.
            iii. The exterior camera shall be provided with surge protectors on both the video cabling and power cabling.
      3) Power for the camera shall be provided by a dedicated power supply with independent outputs each output protected by a circuit breaker.
2. Digital Video Recorder
   a. The video recorder shall provide digital recording capabilities of multiple camera inputs with simultaneous recording of both audio and video. No multiplexer type technology shall be utilized for video recording.
   b. The video recorder shall be a triplex type technology to allow simultaneous monitoring and playback without interrupting recording.
   c. The video recorder shall provide remote viewing capabilities to authorized personal via the facility’s data network.
   d. Pan-tilt-zoom camera control shall be accessible via the video recorder user interface.
   e. Each video recorder camera channel shall provide individual frame rate adjustments and capabilities for continuous, motion detection and alarm detection recording.
   f. The video recorder shall provide alarm input and output ports for interfacing with other security systems.

3. Interface Plate
   a. The Interface plates shall be made of 1/8 inch brushed anodized aluminum with beveled edges, finished in black with 1/8 inch height, white enamel filled lettering unless noted otherwise.

4. Rack Accessories
   a. Rack accessories shall be made of 11 gauge aluminum and finished in black powder coat.

2.3 WIRE AND CABLE
A. This equipment shall as a minimum conform to the following specifications. Cable conductor and gauge requirements may vary depending on device requirements. Contractor to determine and utilize cables with proper conductor and gauge requirements to provide optimum operation of system devices. Use Plenum equivalent cable as required.
1. Camera Control: This cable shall be a Shielded Twisted Pair, four 24 AWG stranded conductor.
2. Camera Power: This cable shall be an Unshielded Twisted Non-Pair, (2) 18 AWG stranded conductors.
3. Camera Video: This cable shall be a Shielded/Coaxial one 18 AWG solid conductor (RG59), 75 ohm.
4. Communications System Cable: Refer to Division 27 Specification Section Communication – General Requirements and its sub-specification sections.
5. Contact Closure: This cable shall be an Unshielded Twisted Non-Pair, two 18 AWG stranded conductor.
6. Network Patch Cords: Provide patch cords as required by the devices to be served. Patch cable types shall be as specified in Division 27 Specification Section Communication – Patch Cords.
7. RS-485 Serial Communication: This cable shall be a Shielded Twisted Pair, four 24 AWG stranded conductor.

PART 3 - EXECUTION

3.1 GENERAL
A. The Contractor shall closely coordinate with the Owner to ensure that Owner provided equipment is procured, configured (as necessary), and installed (as necessary) with ample lead time prior to the Contractor’s use of the equipment.
B. The Contractor shall closely coordinate with the Owner to ensure that Owner provided software is procured, configured (as necessary), and installed (as necessary) with ample lead time prior to the Contractor’s use of the equipment.
C. The Contractor shall coordinate closely with the Owner to gather all network related information required to install the Video Surveillance System. This shall include but not be limited to; port allocation, IP addressing, bandwidth requirements, QoS and PoE.

D. Refer to Division 27 Specification Section - Security General Requirements for execution requirements.
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SECTION 27 62 00
SECURITY - ACCESS CONTROL SYSTEM

PART 1 - GENERAL

1.1 SUMMARY
A. This Section defines the Security System requirement for the Access Control System.

1.2 RELATED SECTIONS
A. The requirements of Division 27 Specification Section Security - General Requirements shall serve as the basis for the requirements of this Section, and are incorporated by reference into this Section.

1.3 SYSTEM DESCRIPTION
A. The Access Control System shall interface with other systems within the facility. Systems shall interface through hardware connectivity including but not limited to network / serial communication, contact closure and voltage / ground reference, The Access Control System Contractor shall closely coordinate with other trades to ensure a fully functional, operating and integrated system ready for the Owner’s use. The Access Control System shall interface with the following systems:
1. Video Surveillance System: Provide video monitoring for areas of access control alarms

B. The primary function of the Access Control System is to secure / monitor selected building entry locations from unauthorized entry. The Access Control System shall include but not be limited to a database application(s), access control processing equipment, communication equipment, verification devices, a monitoring station(s), power supplies, any necessary cabling and door hardware equipment to provide a fully functional and operating system ready for the Owner’s use.
1. The existing Access Control System Database shall reside within a remote location outside this facility. The Database software shall be upgraded and reconfigured as required to incorporate the addition of the new Access Control System requirements. The Contractor shall provide all necessary software upgrades to provide a fully functional and operating system ready for the Owner’s use. The Database configurations shall be implemented by the Owner. The Contractor shall assist the Database configuration, which shall include but not limited to: programming, troubleshooting, testing and verification of system operation.
2. The Contractor shall provide communication via the Owner provided Data Network System to incorporate this Access Control System onto the existing Access Control Network. The ACS system shall be interconnected to the UCB Security network, which is a VLAN on the campus’ ITS network. Access control events shall be stored within the existing Access Control System Database which resides in a remote location outside of this facility. ACS workstations in Facilities and CU Police Dispatch shall have authorization to monitor and control the system remotely over the Security network, coordinate with Owner.
   a. Structured Cabling: Structured cabling required for the direct operation of the Access Control System shall be provided by the Communication Contractor. Structured cabling shall include but not limited to fiber optic and copper cabling.
   b. Data Communications Equipment: Data communications equipment required for the direct operation of the Data Network System shall be provided by the Owner. Data communication equipment shall include but not limited to repeaters, switches and routers.
      1) The Contractor shall coordinate with the Owner to ensure all Data Network System requirements have been provided; this is to include but not limited to patch panel configuration, switch/ router allocation, IP addressing and network security.
c. Data Termination Equipment: Data termination equipment that reside outside of the Owners Data Network but is required for the direct operation of the Access Control System shall be provided by the Contractor. Data termination equipment shall include but not limited to switches / routers, protocol converters, computers, network interface cards, network modules, serial servers and/or patch cabling.

1) Network termination equipment that the Access Control System Database application(s) is to be installed upon shall be provided by the Owner. This shall include but not limited to computers and data servers.

3. The Access Control System shall operate within the parameters set forth below:

a. The Access Control System shall be capable of stand alone operation in the event that communication is interrupted between the local system and the Network Database.

b. The Access Control System shall have battery back-up power for continued operation of entire system in the event of a power outage. This shall include but not be limited to the Access Control System panels and lock power supplies.

c. The Access Control System shall provide monitoring of the facility, this is to include but not be limited to:

1) Events within standard door operation: the following actions shall occur upon a valid card read:
   a) Door alarm shall be shunted and return to alarmed state after door closure.
   b) Card holder information shall display at all Monitoring Stations, as applicable.
   c) Card holder information shall register within an events log.

2) Events outside of standard door operation: the following actions shall occur upon an unsecure status including but not limited to force open, hold open and latch obstruction situations:
   a) A visual / audible notification shall display at all Monitoring Station, as applicable.
   b) An associated camera image of the event shall record at full resolution / frame rate.
   c) The event shall register within an events log.

d. The Contractor shall provide connectivity to all door hardware, as applicable, to ensure the Access Control System operates within the parameters set forth herein. The Contractor shall provide door hardware as specified in the Product section herein. All other door hardware shall be provided by others. The Security Contractor shall coordinate with Door Hardware Contractor to ensure all door hardware operates as indicated in Construction Documents. The Access Control System shall provide operation for doors consistent with the following:

1) Secured side access:
   a) The door shall remain locked to unauthorized personal at all times except during times of building operation. Coordinate building operation schedule with Owner.
   b) Authorized personnel shall present identification card to card reader unit, upon database verification, access shall be granted. The automatic door opener feature, if applicable, shall be available only after personnel are granted access. The door shall remain unsecured for 7 seconds before returning to a secure state.
   c) The door shall maintain a Fail Secure state in the event of a power outage, unless noted otherwise.

2) Unsecured side access:
   a) The door shall provide free egress from building at all times.
   b) Egress shall be provided by means of a mechanical release located within the door hardware (non-magnetic locks) or an electromechanical switch located within door handle, exit device or door frame (magnetic locks).
   c) The automatic door opener feature, if applicable, shall be available at all times.

3) Hold open equipped doors: The Access Control System shall incorporate functionality of door hold open equipment. The Contractor shall coordinate with Fire Alarm Contractor and Owner for additional operation requirements.
e. The Access Control System Monitoring Station shall be located within an Owner specified location. The Monitoring Station shall consist of but not be limited to a computer(s), LCD monitor(s), and Monitoring Software. All components necessary for a fully functional and operational Monitoring Station shall be provided by the Owner.

f. The Access Control System shall interface with other non-security system within the facility, this is to include but not be limited to:
   1) Fire Detection Control System: The Access Control System shall interface with the fire detection control equipment. The Contractor shall coordinate the functionality of the Access Control System during the activation of the fire alarm with Authorities Having Jurisdiction and the Owner.
   2) Elevator Control System: The Access Control System shall interface with the elevator control equipment providing individual floor access based on database verification. The card reader device shall be located within the elevator cab. In the event of fire and/or power outages, the elevator shall operate without restrictions from the Access Control System. The Contractor shall coordinate with Owner for operation requirements.

g. The Access Control System shall provide capability for a “Lock Down” situation. The Owner’s “Lock Down” procedural standards shall set the precedence to which the Access Control System shall be programmed and / or configured. The system shall provide but not be limited to:
   1) Initiation of the “Lock Down” operations
   2) Release all door hold open hardware
   3) Secure all controlled doors (i.e. disable schedule events)

**PART 2 - MATERIALS**

**2.1 GENERAL**

A. Manufacturer: Unless otherwise indicated, equipment in this Section shall be the standard products of a manufacturer regularly engaged in the manufacture of such products. All components used in the system shall be commercial designs that comply with the Specifications. Each major component of equipment shall identify the manufacturer’s name, model and serial number. Items of the same classification shall be identical. This includes equipment, modules, parts, and components. The Engineer retains the right to reject products which reflect, in the Engineer’s opinion, sub-standard design practices, manufacturing procedures, support services, or warranty policies.

1. Unless otherwise indicated, the equipment by the following manufacturers shall not be substituted. The Contractor shall provide the most current model and/or version of product available by listed manufacturer at time of procurement:
   a. Software House

B. Part Numbers: Refer to the equipment schedule at the end of this Section and/or within the drawings for specific part numbers. Part numbers listed in the equipment schedule define the performance specifications for the parts and shall be per the most recent manufacturer’s cut/data specification sheets available at the time of bid. If no part number is provided, then any part meeting the requirements specified is acceptable.

C. Provide materials in quantities as required to provide a fully functional and operational Access Control System.

D. Owner Provided Contractor Installed: Refer to the equipment schedule at the end of this Section for procurement requirements. Equipment identified with an “OFCI” shall be provided by Owner for the Contractor to install.
2.2 EQUIPMENT SPECIFICATION

A. This equipment shall as a minimum conform to the following specifications:

1. Access Control Processing Equipment
   a. The access control processing equipment shall provide capacity for current door requirements as referenced in drawings with the ability to expand for future Access Control needs.
   b. The processing equipment shall have a dedicated power supply with battery charger. In the event of power outage, the system shall have a minimum of 7 Amp hours of battery back-up power.
   c. Contractor to verify power requirements of processing equipment prior to installation.

2. Auxiliary Relay
   a. The relay shall be of a blade type construction with a double pole, double throw contact configuration.
   b. The coil and contact ratings shall exceed the inline current and voltage requirement of the relay controlled devices.

3. Card Reader
   a. The card reader shall be a proximity type card reader, unless noted otherwise.
   b. The card reader shall have battery back up power in the event of power outages.
   c. All exterior card readers shall have surge protectors to protect against lightening.

4. Interface Plate
   a. The Interface plates shall be made of 1/8 inch brushed anodized aluminum with beveled edges, finished in black with 1/8 inch height, white enamel filled lettering.

5. Lock Power Supply
   a. The power supply shall be a dedicated, voltage selectable power supply with battery charger. In the event of power outage, the system shall have a minimum of 7 Amp hours of battery back-up power.
   b. Contractor to verify power requirements of processing equipment prior to installation.

6. Reader Interface
   a. The Reader Interface shall provide inputs for card readers, door positions and request to exit switches.
   b. The Reader Interface shall provide outputs for lock controls and alarm closures.
   c. The Reader Interface shall communicate with the access control processing equipment via a data signal type protocol.

2.3 WIRE AND CABLE

A. This equipment shall as a minimum conform to the following specifications. Cable gauge and conductor quantity requirements may vary depending on device requirements. Contractor to determine and utilize cable with proper conductor and gauge requirements to provide proper operation. Use Plenum equivalent cable as required.

1. Card Reader: This cable shall be a Shielded/Twisted/Pair, (6) 18 AWG stranded conductors.

2. Card Reader Power: This cable shall be an Unshielded Twisted Non-Pair, (2) 18 AWG stranded conductors.

3. Communications System Cable: Refer to Division 27 Specification Section Communication – General Requirements and its sub-specification sections.

4. Contact Closure: This cable shall be a Shielded Twisted Pair, (2) 18 AWG stranded conductor.

5. Lock Power: This cable shall be an Unshielded Twisted Non-Pair, (2) 16 AWG stranded conductors.

6. Network Patch Cords: Provide patch cords as required by the devices to be served. Patch cable types shall be as specified in Division 27 Specification Section Communication – Patch Cords.
7. Power Supply: This cable shall be an Unshielded Twisted Non-Pair, (2) 18 AWG stranded conductors.
8. RS-485 Data: This cable shall be a Shielded Twisted Pair, (4) 22 AWG stranded conductors.

PART 3 - EXECUTION

3.1 GENERAL
   A. The Contractor shall closely coordinate with the Owner to ensure that Owner provided equipment is procured, configured (as necessary), and installed (as necessary) with ample lead time prior to the Contractor’s use of the equipment.
   B. The Contractor shall closely coordinate with the Authority Having Jurisdiction to ensure that all local codes and building requirements are met. Contractor shall provide all documentation required to pass Certificate of Occupancy.
   C. Refer to Division 27 Specification Section - Security General Requirements for execution requirements.
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SECTION 28 31 00
ADDRESSABLE FIRE ALARM SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of contract, including General and Supplementary conditions and Division-1 specification sections, apply to work of this section.

B. Division 26, Basic Electrical Materials and Methods apply to work specified in this section.

C. Division 26 “Electrical Identification” apply to work in this section for labeling of conduit and equipment.

D. Related work specified in other divisions of these specifications.
   1. Installation of duct type smoke detectors.
   2. Control wiring from Fire Alarm Control equipment to mechanical fans, dampers, control equipment both low voltage and line voltage and all other control wiring associated with mechanical equipment.

1.2 SUMMARY

A. Provide a complete and coordinated Class B wiring, fire alarm system in accordance with the contract documents. Audible intelligibility shall be provided throughout the building.

B. Any fire alarm devices, wiring etc., not indicated on the drawings, but required by the local Building Department and Fire Department, shall be provided as part of this specification.

C. Refer to Fire Alarm Matrix for sequence of events.

1.3 SUBMITTALS

A. Procedure - prepare and make submittals listed in accordance with Division 1, “Submittals” as required by Engineer of Record and the Authority Having Jurisdiction (AHJ).

B. Product Data - submit manufacturer’s specifications, recommendations, and installation instruction for use intended. The data shall include but is not limited to the following:
   1. Control panels
   2. Cabinets
   3. Annunciation
   4. Initiating and notification device product data
   5. Locations of alarm initiating and notification appliances
   6. Batteries and battery calculations
   7. Battery charger
   8. Installer’s training history
   9. Addressable interface devices
   10. Central processing unit
   11. Network connections
   12. Wiring conductors including UCB wiring installation guide
   13. Wire connectors
   14. Voltage drop calculations
15. The interface of fire control functions and sequence of operations
16. Electromagnetic door hold-open devices
17. Remote alpha numeric LCD annunciators with control capabilities.
18. Manufacturer’s recommended calibrated test method for smoke sensors and smoke detectors.
19. Include Underwriters Laboratories or Factory Mutual listing cards for equipment provided.

C. Drawings

1. Detailed drawings for the fire alarm system shall consist of illustrations, schedules, performance charts, battery calculations, point lists, instructions, diagrams, and complete detailed drawings of the fire alarm system.
2. A descriptive index of drawings in the submittal with drawings listed in sequence by drawing number.
3. A legend sheet identifying device symbols, nomenclature, and conventions used in the package. Symbols shall match University Standards.
4. Floor plans drawn to a scale not less than 1/8-inch equals 1 foot which clearly show locations of devices, equipment, risers, panels, electrical power connections, approximate location of conduit runs, and other details required to clearly describe the proposed system.
5. A ¼” scale plan view of the Fire Alarm Control Panel with dimensioned layout of all equipment therein. Include elevation of FACP and associated auxiliary panels.
6. Location of control panels, detectors, supervisory switches, manual pull stations, visual/audible alarms and electrical devices. Clearly and completely indicate the function of the control panel and devices. Indicate conduit routing and sizes, and the number of conductors contained in each. Indicate points of connection and terminals used for electrical field connections in the system, with a wiring color code. Indicate termination points of devices and indicate the interconnection of modules required for proper operation of the system. Indicate interconnection between modules and devices. Control diagrams shall be supplemented with a narrative description of the system. Point-to-point wiring diagrams shall indicate control panel wiring and make and model of devices and equipment. Signal circuit diagrams shall show current draw and load by device and by circuit.

D. Design Data

1. Battery standby power requirements calculations.
2. Submit design calculations for the system substantiating battery standby power requirements, calculations showing battery capacity and supervisory and alarm power requirements.

E. Field Test Reports

1. Preliminary and acceptance tests.
2. Include the control panel and initiating and indicating devices, a unique identifier for each device with an indication of test results, and signature of the factory-trained technician of the control panel manufacturer and equipment installer. With reports on preliminary tests, include printer information.

F. Record Drawings

1. Upon completion, and before final acceptance of the work, submit a complete set of CADD generated as-built drawings for the fire alarm system, including components and any other associated appurtenances. Include as-built circuit diagrams complete with conductor color codes and a listing of initiating device locations and fixing voltage for each. Provide CAD disk of entire project. Submit as-built drawings in addition to the
record drawings required by Division 1, “Operation and Maintenance Data”. Provide CAD drawings in standard campus format.

2. List of FACP alphanumeric address names
3. Request for formal inspection and tests
4. When tests have been completed and corrections made, submit a signed, dated certificate with a request for formal inspection and tests.

G. Operation and Maintenance Manuals

1. Four sets of complete as-built drawing the same size as the original drawings and two CAD disk containing all the items of “B” above corrected to include all shop drawing comments and reflect actual space installation. The CAD drawings shall be based on campus CAD standards available from the Facilities Management CAD office.
2. Complete schematic and interconnection wiring diagrams, internal and external, including junction box wiring with all terminal strip and wire numbers.
3. Parts list including complete parts price list and recommended spare parts list.
4. Warranty documentation.
5. Submit in accordance with Division 1, “Operation and Maintenance Data”.

1.4 QUALITY ASSURANCE

A. Qualifications the manufacturer’s authorized distributor must substantiate that within a 50 mile radius of the job site, there is an established agency which stocks a full compliment of parts and offers full service during normal working hours on all equipment to be furnished and that the agency will supply parts without delay and at a reasonable cost.

B. Qualifications of Installer: Prior to installation, submit data for approval showing that the Contractor has successfully installed addressable, analog intelligent interior fire alarm systems of the same type as specified herein, or that the Contractor has a firm contractual agreement with a subcontractor having such required experience. Include the names and locations of at least two installations where the Contractor, or the subcontractor referred to above, has installed such systems. Indicate the type and design of each system and certify that each system has performed satisfactorily in the manner intended for a period of not less than 18 months. Submit names and phone numbers of points of contact at each site.

C. Codes and Standards: Except as modified by governing codes and where more stringent standards are specified by the contract documents, comply with the latest applicable provisions and the latest recommendations of the following:

5. Local and City Codes and Amendments.
8. University of Colorado at Boulder (UCB) Standards.

D. Federal Specifications Compliance: Comply with FED-STD-595 and UCB Standards. When conflict exists, coding requirements of UCB shall govern.
E. Guarantee - all components, parts and assemblies supplied by the manufacturer shall be guaranteed against defects in materials and workmanship for a period of 12 months upon acceptance. Warranty service shall be provided by a trained specialist of the equipment manufacturer. The specialist shall be based in a fully-staffed branch office located within 50 miles from the job site.

F. Testing - conduct a total system test for Architect/Engineer and Local Fire Department. Tests shall include as a minimum.

1. Verify operation of all manual pull stations and detectors.
2. Verify line supervision of each initiating and indicating circuit.
3. Verify all elevator recalls and shunt trip operations.
4. Verify operation of all indicating devices.
5. Verify operation of all alarm initiated function.

G. All equipment provided as part of this section shall be the product of a single fire alarm equipment manufacturer.

H. Equipment and devices shall be from a manufacturer who has been manufacturing similar products for a minimum of 5 years. Furnish materials and equipment that are current products of one manufacturer regularly engaged in the production of such equipment.

I. Regulatory Requirements

1. Devices and equipment for fire alarm service shall be listed by Underwriters Laboratories, Inc. and listed in UL FPKD or approved by Factory Mutual and listed in FM P7825. The omission of these terms under the description of any item of equipment described shall not be construed as waiving this requirement.

J. Requirements for Fire Protection Service

1. Equipment and material shall have been tested by Underwriters Laboratories, Inc. and listed in UL FPKD or approved by Factory Mutual and listed in FM P7825. The omission of these terms under the description of any item of equipment described shall not be construed as waiving this requirement.

K. Standard Products

1. Materials and equipment shall be standard new products of a manufacturer regularly engaged in the manufacturer of such products. Select material from one manufacturer, and not a combination of manufacturers, for any particular classification of materials.

L. Modification of References

1. In NFPA publications referred to herein, consider advisory provisions to be mandatory, as though the word “shall” had been substituted for “should” wherever it appears; interpret reference to “Authority Having Jurisdiction”.

1.5 DELIVERY, STORAGE AND HANDLING

A. Protect equipment delivered and placed in storage from the weather, humidity and temperature variation, dirt and dust, and other contaminants.
PART 2 - PRODUCTS

2.1 SYSTEM DESIGN

A. Acceptable Manufacturers: Simplex-4100U, Notifier.

B. Scope

1. The work covered by this section of the specifications includes the furnishing of all labor, equipment, materials, and performing all operations in connection with the installation of the multiplex addressable Fire Alarm System (Class B) as shown on the drawings, as hereinafter specified, and as directed by the architect/engineer.

2. The Fire Alarm System shall consist of all necessary hardware and software equipment to perform the following functions:
   b. One-way Supervised Automatic Voice Alarm Operations.
   d. Interface to the campus police emergency communication system.
   e. Two-way voice communication systems.

3. Each item of the Fire Alarm System shall be listed as a product of a single fire alarm system manufacturer under the appropriate category by the Underwriters’ Laboratories, Inc. (UL), and shall bear the “U.L.” label. The Control Equipment for all Systems shall be listed under UL category UOJZ as a Single Control Unit.

4. The complete installation shall conform to the applicable sections of NFPA-72, NEC 76, Life Safety Code 101, and Local Authorities Having Jurisdiction.

5. Nodes as defined for this specification shall be intelligent, microprocessor based devices that connect to, and handle network communications.

6. By programmable selection at each node:
   a. The specific detail information of any point connected to any node in the network may be made accessible (declared public) to the network.
   b. Points within each node shall be able to be grouped by area, type of device, type of function, or any other user selectable category, and custom labeled as a point list. A point list shall be acted upon as though it was a point for purposes of interaction with the node custom control program. Detail information shall not burden the point list messages, only the quantity and type of status shall be broadcast into the network.

7. The fire alarm system shall be integrated with the campus primary monitoring host computer. The host system shall be connected to the fire alarm control panels via the campus multimode fiber network. Coordinate with the CU Fire Systems Group. Provide all required software and programming changes to campus GUI prior to final testing.

8. Survivability: When wiring connecting the FACP to any remote mounted controlling device exceeds 100 feet; the wire shall be 2-hour rated in addition to being in conduit.

C. Alarm System

1. Furnish and install a fully field programmable/addressable analog fire detection system. The System shall determine the number and types of modules installed, the number of analog addressable loops, and all installed devices. It shall determine the type of device and the device number. The System shall use Class B signaling line circuits and Class B indicating appliance circuits with individual device supervision and annunciation, primary and secondary supervision, and interfaces to the campus police emergency response system. Include control panels, central processing unit, microphone, signal zone selectors, manual pull stations, smoke sensors, thermal sensors, addressable input interface devices, control and isolation devices, analog/addressable loop modules, audio/visual devices, visual devices, wiring, connections to devices, outlet boxes, junction
boxes, and other necessary material for a complete operating system. System shall allow for loading or editing special instructions and operation sequences as required. System shall be site programmable to accommodate and facilitate expansion or changes. System shall be capable of generating the programming necessary to establish a fully functional general alarm system upon initialization. Software operations are to be stored in a non-volatile programmable memory. Loss of primary and secondary power shall not erase the instructions stored in memory. Selective input/output control functions based on ANDing, ORing, NOTing, timing and special coded operations shall be incorporated in the resident software programming of the system.

D. Job Site Changes

1. To accommodate and facilitate job site changes, initiating and indicating circuits shall be individually configurable on site to provide either alarm/trouble operation, alarm only, trouble only, current limited alarm, no alarm, normally closed device monitoring, a non-latching circuit or an alarm verification circuit.

E. Operations

1. Display
   a. Under normal condition, front panel shall display a “SYSTEM NORMAL” or equivalent message and the current time and date.

2. Sequence of Operation
   a. Operation of manual stations or activation of area smoke sensors and thermal sensors including any manual or automatic initiating device shall cause the following unless noted otherwise:
      1) Annunciate device type, location by building, floor, circuit and time on FACP mounted alphanumeric display and at campus monitoring graphic user interface computer.
      2) Automatic Voice Evacuation Sequence shall perform as outlined below:

      The audio alarm signal shall consist of a “Slow Whoop” alarm tone for a maximum of 15 seconds followed by automatic pre-selected voice evacuation messages. At the end of each voice evacuation message, the “Slow Whoop” alarm tone shall resume. The alarm tones shall sound alternately until the signal silence switch at the FACP has been operated.

      3) Refer to Fire Alarm Matrix at the end of this specification.

3. Abnormal Conditions
   a. Panel shall display the following information relative to the abnormal condition of a point in the system:
      1) Alphanumeric custom location label (minimum of 30 alphanumeric characters.)
      2) Type of device.
      3) Point status.

4. Alarm or Trouble Condition
   a. Pressing the appropriate FACP acknowledge button shall acknowledge the alarm or trouble condition. After the points have been acknowledged, the LEDs shall glow steady and the panel audible signal will be silenced. Total number of alarms, supervisory and trouble conditions shall be displayed along with a prompt to review each list chronologically. End of the list shall be indicated.

5. System Reset
   a. “System Reset” button shall be used to return to its normal state after an alarm condition has been remedied. The display shall step the user through the reset process.
   b. Should an alarm condition continue to exist, system will remain in an abnormal state. System control relays shall not reset. The panel audible signal and the
alarm LED shall be on. The display will indicate the total number of alarms and troubles present in the system along with a prompting to review the points.

6. History Logging
   a. The control panel shall have the ability to store multiple events in an event buffer. These events shall be stored in a battery-protected memory. Events shall also be printed to the alarm printer.

7. Access Levels
   a. There shall be a minimum of four access levels provided for operators and supervisors via user-defined pass codes. Changes to pass codes shall be made only by authorized personnel.
   b. Should an invalid code be entered the operator shall be notified with a message.
   c. Access to a level will only allow the operator to perform actions within that level and actions of lower levels, not higher levels.
   d. The following functions shall have access levels associated with them:
      1) System Reset
      2) Set Time/Date
      3) Manual Control
      4) On/Off/Auto Control
      5) Disable/Enable
      6) Clear Historical Log
      7) Change Alarm Verification
      8) Program Update

8. Detection Operation (Smoke Sensors)
   a. Smoke sensors shall be smoke density measuring devices having no self-contained alarm set point (fixed threshold.) The alarm decision for each sensor shall be determined by the fire alarm control panel. The control panel shall determine the condition of each sensor by comparing the sensor value to the stored values.
   b. Control panel shall maintain a moving average of the sensors' smoke chamber value to automatically compensate (move the threshold) for dust and dirty conditions that could affect detection operations. System shall automatically maintain a constant smoke obscuration sensitivity for each sensor (via the floating threshold) by compensating for environmental factors. Smoke obscuration sensitivity shall be adjustable at least twice a day and within UL 26B window (0.5 percent to 4.0 percent) to compensate for any environment.
   c. System shall automatically indicate when an individual sensor needs cleaning. When a sensor’s percentage of compensation reaches a predetermined value, a “DIRTY SENSOR” trouble condition or similar display shall be audibly and visually indicated at the control panel for the individual sensor. Additionally, the LED on the sensor base shall glow steady giving a visible indication at the sensor location. To prevent false alarms, these “DIRTY” conditions shall in no way decrease the amount of smoke obscuration necessary for system activation.
   d. Control panel shall perform an automatic self-test routine on each sensor which will functionally check sensor sensitivity electronics and ensure the accuracy of the values being transmitted to the control panel. Sensors that fail this test shall indicate a trouble condition with the sensor location at the control panel.
   e. An operator at the control panel, having a proper access level, shall have the capability to manually access the following information for each initiating device:
      1) Primary status
      2) Device type
      3) Present average value
      4) Present sensitivity selected
      5) Sensor range (normal, dirty, etc.)
   f. An operator at the control panel, having a proper access level, shall have the capability to manually control the following for each sensor:
      1) Alarm detection sensitivity values.
2) Enable or disable the point.
3) Control a sensor’s relay driver output.

g. It shall be possible to program the control panel to automatically change the sensitivity settings of each sensor based on time-of-day and day-of-week (for example, to be more sensitive during unoccupied times and less sensitive during occupied periods.)

h. Control panel shall have the capability of being programmed for a pre-alarm or two-stage function. This function allows an indication to occur when, for example, a 3 percent sensor reaches a threshold of 2.5 percent smoke obscuration.

i. For increased smoke detection assurance, individually addressed smoke sensors shall be provided with field adjustable alarm verification. Only a verified alarm shall initiate the alarm sequence operation. System shall be initially set up with a 30-second verification period.

9. Detection Operation (Thermal Sensors)
a. Thermal sensors shall be combination rate-of-rise/fixed temperature sensing. The alarm decision for each sensor shall be determined by the fire alarm control panel. The control panel shall determine the condition of each sensor by comparing sensor value to stored values. Sensor shall have the ability from the control panel to adjust its temperature setting.

b. Control panel shall maintain a moving average of the sensors’ heat sensing value to automatically compensate (move the threshold) for dust and dirty conditions that could affect detection operations. System shall automatically maintain a constant heat sensing sensitivity for each sensor (via the floating threshold) by compensating for environmental factors.

c. System shall automatically indicate when an individual sensor needs cleaning. When a sensor’s percentage of compensation reaches a predetermined value, a “DIRTY SENSOR” trouble condition or similar display shall be audibly and visually indicated at the control panel for the individual sensor. Additionally, the LED on the sensor base shall glow steady giving a visible indication at the sensor location. To prevent false alarms, these “DIRTY” conditions shall in no way decrease the amount of heat sensing necessary for system activation.

d. Control panel shall perform an automatic self-test routine on each sensor which will functionally check sensor sensitivity electronics and ensure the accuracy of the values being transmitted to the control panel. Any sensor that fails this test shall indicate a trouble condition with the sensor location at the control panel.

e. An operator at the control panel, having a proper access level, shall have the capability to manually access the following information for each initiating device:
   1) primary status
   2) Device type
   3) Present average value
   4) Present sensitivity selected
   5) Sensor range (normal, dirty, etc.)

f. An operator at the control panel, having a proper access level, shall have the capability to manually control the following for each sensor:
   1) Alarm detection sensitivity values.
   2) Enable or disable the point.
   3) Control a sensor’s relay driver output.

F. Primary Power

1. Obtain primary power 120 VAC 60hz, at the emergency panel in the electrical room location as indicated. Primary power source shall be identified FIRE ALARM SYSTEM with white letters on a red background engraved plastic sign permanently affixed to the face of the switch. Install lock clips on circuit breakers in the “ON” position.
G. Auxiliary Power (Secondary Power)

1. Provide for system operation in the event of primary power source failure. Transfer from normal to auxiliary (secondary) power or restoration from auxiliary to normal power shall be automatic and shall not cause transmission of a false alarm.
   a. Batteries
      1) Provide rechargeable lead acid type with sufficient ampere-hour rating to operate the system under supervisory and trouble conditions, including audible trouble signal devices for 24 hours and audible and visual signal devices under alarm conditions for an additional 15 minutes. House batteries either within the control panel or in a separate substantial steel cabinet.
   b. Battery Charger
      1) Provide solid state automatic float type, capable of recharging completely discharged batteries to fully charged condition in 24 hours or less. Locate charger within the control panel or within the battery cabinet.

H. Wiring

1. Conductors
   a. Provide in accordance with NFPA 70 and NFPA 72. Conductors shall be copper. Conductors for 120/208 volt circuits shall be No. 12 AWG minimum; single conductors for low-voltage dc circuits shall be a minimum No. 18 AWG twisted, shielded with drain wire minimum. Conductors shall be color-coded. Provide wiring in electrical metallic tubing conduit in dry locations not enclosed in concrete or where not subject to mechanical damage. Conceal conduit in finished areas. Identify conductors within each enclosure where a tap, splice, or termination is made. Identify conductors by plastic-coated, self-sticking, printed markers or by heat-shrink type sleeves. Wire the alarm initiating and notification signal devices so that removal will cause the system trouble device to sound. Each conductor used for the same specific function shall be distinctively color-coded. Use two different color codes for each interior alarm circuit; one for each loop. Each circuit color code wire shall remain uniform throughout circuit. Plenum rated cable can be used where approved by engineer and is concealed but accessible.
   b. Color code and minimum wire sizes for the fire alarm system as follows: All wire is solid copper insulation type per NEC 760. All wiring colors shall match UCB standards and shall be clearly identified in the as-built drawings.

<table>
<thead>
<tr>
<th>Circuit Type</th>
<th>Colors of Wire</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire Alarm Zones</td>
<td>Red + Black -</td>
<td>14 THHN</td>
</tr>
<tr>
<td>MapNet</td>
<td>Red + Black -</td>
<td>18 Twisted Shielded</td>
</tr>
<tr>
<td>Communication Line (Miniplex or LCD)</td>
<td>Red + Black -</td>
<td>18 Twisted Shielded</td>
</tr>
<tr>
<td>Audio Riser (Vertical Runs)</td>
<td>Red+Black -</td>
<td>12 Twisted Shielded</td>
</tr>
<tr>
<td>Horns</td>
<td>Red+Black -</td>
<td>#14 THHN Jacketed Cable (2 Conductor)</td>
</tr>
<tr>
<td>Strobes (Visuals)</td>
<td>Yellow +Brown -</td>
<td>14 THHN</td>
</tr>
<tr>
<td>Speakers (Horizontal Runs)</td>
<td>Red + Black -</td>
<td>14 Twisted Shielded</td>
</tr>
<tr>
<td>24VDC Power</td>
<td>White+Black -</td>
<td>14 THHN</td>
</tr>
<tr>
<td>Door Holders (24VDC)</td>
<td>Blue +White -</td>
<td>14 THHN</td>
</tr>
<tr>
<td>Remote Test Switches</td>
<td>White/White</td>
<td>16 THHN</td>
</tr>
<tr>
<td>Remote Lights</td>
<td>Red +Black -</td>
<td>16 THHN</td>
</tr>
<tr>
<td>Fan Controls</td>
<td>Gray(N/C)/Pink(N/O)/Orange(Common)</td>
<td>14 THHN</td>
</tr>
</tbody>
</table>
2. Terminations
   a. Connections, junctions and conductor terminations shall be made with screw terminals at risers only. Terminate strips everywhere except in control panels. Terminations with operating voltage of 50 volts or more shall be provided with protective cover and shall be labeled with the voltage.

2.2 COMPONENT DESIGN

A. Fire Alarm Control Panel (FACP)

1. Requirements
   a. FACP shall comply with the applicable requirements of UL 864. Panel shall be modular, installed in a surface-mounted steel cabinet with cylinder lock. The door shall be hinged to allow access for service. Control panel shall be a neat, compact assembly containing components and equipment required to provide the specified operating and supervisory functions of the system. Control panel switches shall be within the locked cabinet. A suitable means shall be provided for testing the control panel visual indicating devices. Each initiating circuit shall be powered and supervised so that a signal on one zone does not prevent the receipt of signals from other zones. Loss of power, including any batteries, shall not require the reloading of a program from any source. Upon restoration of power, start-up shall be immediate, automatic and shall not require manual operation. Loss of primary power or the sequence of applying primary or emergency power shall not affect the transmission of alarm, supervisory or trouble signals. Enclosures shall be provided with ample gutter space to allow proper clearance between the enclosure and live parts of the panel equipment.

   b. Each FACP shall be intelligent, with its own microprocessor and memory. Each FACP shall be UL listed independently as a fire alarm control unit. Each FACP shall be capable of automatically updating the initial System Program to accommodate added or deleted devices on any analog circuit. Each FACP shall be capable of identifying and programming a General Alarm condition for all installed devices. The system shall be capable of identifying the number of analog addressable circuits, the number of devices on all circuits, the device type and location. The System shall be capable of incorporating all new devices into the System program. System shall display at the control panel, the sensitivity of remote addressable photoelectric or ionization smoke sensor devices and thermal...
heat sensor devices. The system shall be capable of displaying 160 characters of system and user text (4x40 alphanumeric display). Control panel shall automatically return the normal mode after a predetermined time (1 hour) after being in the service mode. Addressable devices shall be individually identified by the system, and any quantity of addressable devices shall be in alarm at any time up to the total number connected to the system. Control panel shall be capable of supporting non-addressable as well as addressable devices. The Control panel shall be capable of supporting conventional zones in addition to analog/addressable circuits. The Control Panel shall provide for addressable remote conventional zones that are hardwired to any device addressability as well as remote sensitivity measurement shall be performed on the same pair or wires. System shall be capable of having multiple addressable devices in alarm simultaneously. FACP shall have a service mode to permit the arming and disarming of individual detection or output devices as well as manually operating output devices. Status of these devices shall be displayed upon command from the FACP. Control panel shall automatically return to normal mode in the event the panel remains unattended in the service mode. Control panel shall be able to receive and process alarms even in the service mode. FACP shall be capable of:

1) Smart Start auto initialization.
2) Smart Start Program Update.
3) Program all functions from the FACP front panel.
4) Counting the number of addressable devices within a “circuit” which are in alarm.
5) Counting “circuits” which are in alarm.
6) Counting number of addressable devices which are in alarm on system.
7) Differentiating among types of addressable devices such as ionization smoke sensors, photoelectric smoke sensors, thermal heat sensors, control elements, collective zone interfaces, point identification devices, and manual stations.
8) Assigning priorities to type of detectors, circuits or groups of detectors.
9) Provide remote serial alpha numeric LCD display for all remote annunciator locations.
10) Indicate on FACP alphanumeric display, as a minimum, the following: Building Number, Floor, Type of Device, and Device Address.
12) Automatic evacuation voice message which operates as a two channel system, allowing evacuation tones and voice messages be transmitted simultaneously to different zones. Visual alarms shall operate in unison with voice alarm system.
13) City disconnect.
14) Pre-action system bypass.
15) Elevator bypass.
16) Door holder bypass.
17) Fan/damper bypass.

2. A full set of graphics showing all initiating devices is to be installed on the mainframe graphic command center.
3. Control Functions
   a. Control functions shall be assigned on the basis of system initiation patterns of devices such as “ANDing” groups and “ANDing” types of devices.
4. Supervision
   a. FACP shall supervise each individual device on an initiating circuit such that trouble supervisory, normal, pre alarm and alarm thresholds are individually annunciated. Each device on an addressable initiating circuit shall be checked to include the following: Sensitivity, response, opens, shorts, ground faults, functionality and status.
5. Reporting a Failure
   a. FACP shall report the failure of a device’s transmitting components, open or shorted, on an addressable initiating circuit. Device shall be recognized and identified by location within the circuit to the specific devices, and other devices on the circuit shall continue to function properly.

6. Devices
   a. FACP shall report by specific device and address, any device which has been removed from an addressable initiating circuit, and shall not disrupt the operation of the remaining devices to function. The system shall be capable of sounding a Trouble if the device replaced is a different device type than the device removed.

7. Accessories
   a. FACP shall be completely equipped and be provided with 25 percent spare initiating and indicating circuits, including modules, enclosure space, terminal strips, internal electronic memory and other necessary accessories complete and ready to accept future circuits. The FACP shall be capable of automatically updating the System Program to adjust for such changes.

8. Power
   a. FACP shall provide power necessary for the devices connected to it, including relay and remote annunciators. Provide a green LED to indicate normal system power is functioning.

9. Hardware and Software
   a. Hardware and software which define system configuration and operation shall be provided. Memory data and operating system software shall be contained in a non-volatile memory.

10. Smoke Sensors
    a. Smoke sensors shall be provided with alarm verification with field-adjustable time from 0 to 60 seconds. System shall initially set up with a 30-second verification period.

11. Detector Sensitivity
    a. FACP shall be capable of measuring and adjusting the sensitivity of sensors. Provide an alphanumeric display to display custom messages and give readings of sensor sensitivity, sensor by sensor. It shall not be possible to change the sensor sensitivity from the FACP within maximum and minimum values as defined by the UL listing of the sensors. System shall be capable of listing sensor sensitivity settings on the printer for permanent record.

12. Smoke Obscuration Sensitivity
    a. Control panel shall maintain a moving average of the sensors’ smoke chamber value to automatically compensate (move the threshold) for dust and dirty conditions that could affect detection operations. System shall automatically maintain a constant smoke obscuration sensitivity for each sensor (via the floating threshold) by compensating for environmental factors. The smoke obscuration sensitivity shall be adjustable within the UL 260 window (0.5 percent to 4.0 percent) to compensate for any environment.

13. Dirty Sensor Indication
    a. System shall automatically indicate when an individual sensor needs cleaning. When a sensor’s percentage of compensation reaches a predetermined value, a “DIRTY SENSOR” or equivalent trouble condition shall be audibly and visually indicated at the control panel for the individual sensor. To prevent false alarms, these “DIRTY” conditions shall in no way decrease the amount of smoke obscuration necessary for system activation.

14. Self-Test Routine
    a. Control panel shall continuously perform an automatic self-test routine on each sensor which will functionally check sensor sensitivity and ensure the accuracy of the values being transmitted to the control panel. Any sensor that fails this test shall indicate a trouble condition with the sensor location at the control panel.
15. Resetting and Testing the System
   a. It shall be possible to test, reset and alarm silence from the FACP. New
      unacknowledged alarms and troubles shall be distinctively displayed on both the
      visual display and the printer and differentiated from previous alarm and troubles.
      System shall automatically indicate the total quantity of alarms and trouble which
      have occurred prior to reset at the control unit. No alarm or trouble indication shall
      be resettable until it has been acknowledged. It shall not be possible to reset the
      system until alarms have been acknowledged.

16. FACP Switches
   a. FACP switches shall allow authorized personnel to accomplish the following,
      independent of the main operating console:
      1) Trouble silencing switch which transfers trouble signals to an indicating
         lamp.
      2) Evacuation alarm silencing switch which, when activated during alarm,
         silences alarm devices and, upon clearing the alarm, causes operation of
         the system trouble signals until the switch is returned to the normal position.
         Upon activation of a second alarm while silenced, causes the evacuation
         alarm to re-sound. Operation of the switch when there is no evacuation
         alarm causes operation of the system trouble signals.
      3) Reset zones after initiating devices have been returned to normal.
      4) Perform a complete operation test of the microprocessor with a visual
         indication of satisfactory communications with each board.
      5) Test panel LEDs for proper operation without causing a change in the
         condition on any zone.

17. Field Programming Equipment
   a. Provide field programming equipment, software devices, software, computers and
      other equipment necessary, including interconnection cables to accommodate field
      software programming changes to be made by the owner to change device
      descriptions, sensitivity setting, control, device type and addition or deletion of
      devices.

18. Lockable Equipment
   a. Lockable equipment shall have a keyed lock. All devices and cabinets shall be
      keyed alike.

19. Network Connection: Provide fiber network card to interface with campus fiber network.
20. The system shall be integrated to receive the UCB police department and the service
    center emergency mass notification announcements using a microphone from two
    remote locations.

B. Manual Stations
   1. Provide an addressable noncoded single action type with mechanical reset features.
      Locate stations as indicated. Stations shall be die cast aluminum semi-flush or surface-
      mounted. Surface-mounted boxes shall be painted the same color as alarm station.
      Mount stations with the base at 4 feet above finished floor and no more than 5 feet from
      any door, measured horizontally, as shown. Provide each station with screw-type
      terminals of proper number and type to perform functions required. Break-glass-front
      stations will not be permitted. The manual alarm station shall require a key to reset or
      test.

C. Smoke Sensors
   1. Provide analog addressable smoke sensors of the photoelectric type which shall
      communicate actual smoke chamber values to the system fire alarm control panel.
      Detectors shall be uniquely identifiable to FACP.
   2. Sensors shall be listed to UL 268 and shall be documented compatible with the control
      equipment to which they are connected. Sensors shall be listed for both ceiling and wall-
      mount applications.
3. Each sensor base shall contain a LED that, when the control panel determines that a sensor is in the alarm or trouble condition, the control panel shall command the LED on that sensor’s base to turn on steady, indicating the abnormal condition.

4. Sensor’s electronics shall be immune from false alarms caused by electromagnetic interference and radio frequency interference.

5. All sensor addressing information shall be stored in the fixed base. Addressing information that is stored in the removable sensor is not acceptable.

D. Duct Smoke Detectors

1. Detectors in duct shall be analog addressable photoelectric type and listed by UL or FM for duct installation. Duct detectors shall be provided with approved duct housing, mounted exterior to the duct, and shall be provided with perforated sampling tubes extending across the width of the duct. Activation of duct detectors shall cause actuation of the fire alarm control panel in the same manner as other alarm initiating devices and in addition, cause all air handling units to be deactivated. Detector head shall contain amplifier switching circuitry. The amplifier switching circuit shall be entirely solid-state and operate with a nominal detector line voltage of 24 volts dc. Detectors to be equipped with screw terminals. Detector to be provided with indicating lamp and test switch and in test position bypass fan shutdown feature.

2. Test switch shall be installed 7'-0" AFF in corridors adjacent to corresponding duct detector.

E. Thermal Sensors

1. Provide analog addressable thermal sensors of the combination rate-of-rise and/or fixed temperature type which shall communicate actual heat values to the system fire alarm control panel. Detector temperature setting shall be accomplished via the FACP. Detectors shall be uniquely identifiable to FACP.

2. Sensors shall be listed to UL 268 and shall be documented compatible with the control equipment to which they are connected. Sensors shall be listed for ceiling applications.

3. Each sensor base shall contain an LED that, when the control panel determines that a sensor is in the alarm or trouble condition, the control panel shall command the LED on that sensor’s base to turn on steady, indicating the abnormal condition.

4. Sensor’s electronics shall be immune from false alarms caused by electromagnetic interference and radio frequency interference.

5. Detectors shall be nominal 24 Vdc powered by initiating circuit.

F. Addressable Point Identification Input Module

1. The Point Identification Input Module shall be provided to connect single supervised conventional initiating contact type device such as water flow switches, tamper switches, single detectors, and other such devices to any of the two-wire intelligent analog loop cards. The Point Identification Device shall mount in a 4 inch square, 2 1/8 inch deep electrical box and shall be capable of (Class “B”) supervised wiring to the initiating device. The Point Identification Device shall contain an integral LED that annunciates module activation. The Point Identification Device shall provide address setting means switches and store an internal identifying code which the control panel shall use to identify the type of device.

G. Addressable Control Fire Relay Module

1. The Addressable Control Element shall be provided to connect and supervise, conventional indicating device or zone of indicating devices that required an external power supply, such as horns, strobes to any of the (2) wire intelligent analog loop cards. The Control Element shall be capable of operating as a relay (dry contact form C,) to control door holders, and other such devices. Control Elements shall mount in a 4 11/16
inch square, 3 inch deep electrical box and shall be capable of (Class “A”) supervised wiring to the indicating or control device. Control Element shall contain an integral LED that annunciates module activation. Control Element shall provide address setting means switches and store an internal identifying code which control panel shall use to identify the type of device. The addressable Control element shall be capable of providing feedback to the FACP for positive confirmation of the controlled devices activity.

H. Audio/Visual Alarms
1. Provide recessed and surface-mounted approved combination audio/visual alarm devices consisting of an electronic horn for use in an electrically-supervised circuit and a top-mounted integral flashing strobe light. The alarm horn shall have a sound rating of at least 96 decibels at 10 feet. Provide lamps of the flashing stroboscopic type, powered from the control panel alarm circuit. Lamps shall produce a minimum of 75 candela and be designed for A.D.A. compliance. Lamps shall be protected by a polycarbonate lens and shall be labeled FIRE, and are to be mounted at 80 inches above the floor, unless noted otherwise on the drawings.
2. Visual alarms shall operate in unison with audio alarm system.

I. Visual Alarms
1. Provide flush and surface-mounted lamp assembly suitable for use in an electrically-supervised circuit. Provide lamps of the flashing stroboscopic type, powered from the control panel alarm circuit. Lamps shall produce a minimum of 75 candela and be designed for A.D.A. compliance. Lamps shall be protected by a polycarbonate lens and shall be labeled FIRE, and are to be mounted at 80 inches above the floor, unless noted otherwise on the drawings.
2. Visual alarms shall operate in unison with voice alarm system.

J. Electromagnetic Door Hold-Open Devices
1. Attach to the outlet boxes indicated. Device shall operate on power from the fire alarm control panel. Attach compatible magnetic component to the door. Under normal conditions, the magnets shall attract and hold the door open. Upon activation of the building fire alarm system, the devices shall be de-energized, thus releasing the doors on the circuit. Devices shall be designed for wall or floor mounting as required by location shown on drawings, complete with matching door plate, material and finish to match door hardware. Electromagnet operates from a 24V DC source from an auxiliary fire alarm power supply, and requires no more than 0.070 watts to develop 25 lbs. holding force.

K. Fire Alarm Speakers - High Output
1. Speaker shall be a high efficiency, re-entrant type speaker suitable for voice and tone signals. Speaker shall be able to operate continuously without loss of signal for one hour in any ambient temperature environment from 150°F to -30°F. Speaker shall have a die cast housing and be resistant to water, corrosion, vibration and vermin and shall be imperious to damage from pointed objects. Speaker shall produce a sound pressure level of 87 dB measured at rated power (1 watt) ten (10) feet on axis at 1 Khz.
2. Speakers shall be suitable for semi-flush mounting or recessed as shown on plans. All speakers shall be mounted in the ceiling throughout facility.
3. Speakers shall be addressable with taps from ¼ watt up to 2 watts.
L. **Outdoor Bell**

1. Outdoor bell shall be provided as shown on drawings. Bell shall track the main water flow device.
2. Minimum mounting height is ten (10) feet.

M. **Outdoor Fire Light and Horn**

1. Outdoor fire lights and horn suitable for wet locations complete with high intensity flashing light and alarm horn as integral unit.
2. The electrical light source shall be sealed in silicone and protected by a Lexan lens. The word “fire” shall appear on the lens.
3. The minimum sound level shall be 95 dB at ten (10) feet. Minimum mounting height is ten (10) feet.
4. Outdoor fire light and horn shall track the main water flow device.

N. **Remote Indicator Lights**

1. Remote indicator lights shall be lighted red when the associated device is in alarm. Light shall be mounted in a stainless steel coverplate with the appropriate legend engraved thereon. Indicators shall be a highly visible red LED.

O. **Nameplates**

1. Major components of equipment shall have the manufacturer’s name, address, type or style, model or serial number, catalog number, date of installations, installing Contractor’s name and address, and the contract number provided on a new plate permanently affixed to the item or equipment. Major components include, but are not limited to, the following:
   a. Fire Alarm Control Panels
      1) Furnish to obtain approval by the Engineer/AHJ before installation. Nameplates shall be etched metal or plastic, permanently attached by screws to panels or adjacent walls.

P. **Pre-action System**

1. System shall integrate with the server room and vivarium loading dock pre-action system. Refer to Division 21 for additional interface requirements and sequence of operations.

Q. **Wiring**

1. Provide Wiring materials under this section as specified in division 26, “Wires and Cables”, with the addition and modifications specified herein.

2.3 **MASS NOTIFICATION SYSTEM**

In general, campus buildings shall be provided with Mass Notification System (MNS). Small buildings may not require MNS; examples include very small buildings such as pump houses, lawn equipment storage areas, single family houses on the Hill and similar places. The design team shall coordinate with the campus AHJ and determine whether the building under design needs to be provided with MNS. Only for buildings where it is determined and agreed that MNS is required and that it is combined with the fire detection and alarm system, all applicable paragraphs in this section that refer to MNS shall apply. For buildings where it is determined and agreed that MNS is not required, none of the paragraphs that refer to MNS shall apply. Where the MNS is independent of the fire detection and alarm system, please refer to applicable codes and standards, instead of using this section. Please note that Emergency
Communication System (ECS) and Mass Notification Systems (MNS) are used interchangeably within this document.

1. New Buildings MNS:
   a. The system is to work such that announcements can be made for other emergencies on campus. The new fire alarm control panel shall be capable of receiving audio inputs for announcements over the systems speakers. The panel shall be configured and programmed so that these inputs are a higher priority than a fire alarm (i.e., the audio inputs will override a current or pending fire alarm announcement).
   b. The system is to be able to have emergency announcements can be made using a microphone at the fire alarm control panel and using microphones from two remote campus buildings, e.g., possibly University of Colorado Police Department (CUPD) and the Service Center.
   c. The systems should allow CUPD dispatch to communicate with the occupants via a dial-in connection.
   d. Speakers shall be provided in compliance with the Emergency Voice/Alarm Communications system from NFPA 72.
   e. For emergency voice/alarm communication systems, contractor shall perform intelligibility testing for the building. All large and/or complicated spaces and a random sample of remaining areas shall be tested. Testing shall be performed in accordance with Annex B, Clause B1, of IEC 60849. The system is to exceed the equivalent of a common intelligibility scale (CIS) score of 0.70.
   f. Interior emergency voice/alarm systems shall have speakers installed in accordance with NFPA 72. Speakers are to be provided with integral strobe visual alarm where appropriate. Mounting of all devices shall comply with ADA requirements. Speakers shall be designed and installed to provide voice intelligibility throughout all areas of the building. Provide Wheelock E70/E90 or ET70/ET90 series speakers or as approved by the University.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Refer to UCB Standards for form titled “Installation Guidelines”. Installation must comply with this document.

B. The work includes providing a new fully field programmable/addressable analog interior fire alarm and smoke detection system including associated equipment and appurtenances. Provide each system complete and ready for operation. Equipment, materials, installation, workmanship, inspection, and testing shall be in strict accordance with the required and advisory provisions of NFPA 70, NFPA 72 and NFPA 241, except as modified herein.

C. Provide intelligent, analog addressable type manual pull stations, smoke sensors, thermal sensors, and audio/visual devices, including a stand alone fire alarm control panel as located on the drawings and required by the fire department.

D. Provide additional voice alarm speakers where sound level is not above 15dB above ambient noise level or where instability does not meet the requirement set herein.

E. Pre-inspection - examine areas and conditions under which work of this section is to be performed. Do not proceed with work until unsatisfactory conditions have been corrected.
3.2 INSTALLATION CRITERIA

A. All fire alarm wiring shall be in conduit. All alarm and signal wiring shall be in accordance with the manufacturer’s recommendations and installed in an approved raceway specified in Section 26 05 33. All raceways and boxes located within 6’ of fire sprinkler tamper or flow shall be watertight per UCB standards.

B. The contractors shall fully coordinate with all other trades for the proper wiring and control of all systems.

C. VCS speakers shall be wired in parallel.

D. Control panel and standby power module must be mounted with sufficient clearance for observation and testing. Final arrangement and location must be approved by the Architect/Engineer and Fire Department.

E. Flexible connectors are to be used for all devices mounted in suspended lay-in ceiling panels. All conduit, mounting boxes, junction boxes and panels are to be securely hung and fastened with appropriate fittings to insure positive grounding throughout the entire system. No wiring other than that directly associated with fire alarm detection, alarm or auxiliary functions will be permitted in fire alarm raceways.

F. Conductors in cabinets must be carefully formed and harnessed so that each drops off directly opposite to its terminal. Cabinet terminals must be numbered and coded.

G. Wiring splices are to be avoided to the extent possible, and, if need, they must be made only in junction boxes which are to be painted fire-alarm red. All splices in junction boxes 8” x 8” or larger shall be terminated on a numbered terminal strip.

H. Color codes must be used throughout. Transposing or changing color coding of wire will not be permitted. Wire nut-type connections are not acceptable. All conductors in conduit pull boxes or cabinets containing more than one wire, must be labeled on each end with “E-Z Markers” or equivalent.

I. Provide all necessary emergency power to the complete Fire Alarm System in accordance with the manufacturer’s requirements.

J. Smoke detectors and heat detectors shall not be installed prior to final construction cleaning of the area served.

K. Provide fixed heat detector in vivarium loading dock to activate pre-action system.

L. Refer to UCB Standards for labeling guidelines. Installation must comply with these guidelines.

M. Provide 11x17 plan drawings and locate in FACP.

3.3 PAINTING

A. Paint exposed electrical, fire alarm conduit and surface metal raceway to match adjacent finishes in exposed areas. Paint conduit and surface metal raceways red in unfinished areas and above finished ceilings.
3.4 FIELD QUALITY CONTROL

A. Preliminary Tests: Refer to UCB Testing Standards for testing requirements and required forms. Provide the following testing procedures in addition to the UCB testing requirements.

1. Conduct the following tests during installation of wiring and system components. Correct any deficiencies pertaining to these requirements prior to formal functional and operational tests of the system.
2. Ground Resistance
   a. Measure the resistance of each connection to ground. Ground resistance shall not exceed 10 ohms.
3. Dielectric Strength and Insulation Resistance
   a. Test dielectric strength and the insulation resistance of system interconnecting wiring by means of an instrument capable of generating 500 volts dc and equipped to indicate leakage current in 1000 mega-ohms. For the purpose of this test, instrument shall be connected between each conductor on the line and between each conductor and ground at control panel and of line, with the other extremity open circuited and series-connected devices shunted or in place. System shall withstand test without breakdown and indicate a resistance of not less than 500,000 ohms, the measurement being taken after an electrification of not more than 1.0 minute with a dc potential of not less than 100 volts nor more than 550 volts. Dielectric tests shall be witnessed by Engineer or his designee.
4. Smoke and Thermal Sensor Tests
   a. Prior to formal inspection and tests, clean and perform sensitivity tests on each smoke and thermal sensor. Clean the smoke and thermal sensors in accordance with the manufacturer’s recommended procedures. Perform voltage activation sensitivity test on each sensor and record the results. Remove sensors with a sensitivity level above or below the UL accepted sensitivity range for that sensor and replace with new sensors. Present recorded data at the formal inspection for verification. Approved copies shall become part of the operations and maintenance manual for the fire alarm system.
5. Field Inspection and Test
   a. Before final acceptance of the work, test each system to demonstrate compliance with the contract requirement. Each system shall be subjected, at minimum, to complete functional and operational tests including tests in place of each smoke sensor and detector, each thermal sensor, each manual station and visual and audio/visual device, tests of wiring supervision and tests of control panel functions. Preliminary tests shall be performed in accordance with manufacturer’s published testing instructions and in accordance with NFPA 72. Furnish one extra Operations and Maintenance Manual with the formal request for final acceptance testing. The system shall be operational, with no trouble or alarm conditions, a minimum of 14 consecutive days prior to formal tests. Printer shall be operational during the preliminary tests and break-in period. Provide printer records with the request for formal inspection as evidence of completion of required preliminary test.
6. Formal Inspection and Test
   a. The Authority Having Jurisdiction will witness formal tests after receipt of written certification that preliminary tests have been completed and that the system is ready for final inspection. The system manufacturer’s technical representative shall be present for the inspection and test. At minimum, preliminary tests shall be repeated and functional and operation tests conducted, as requested by the Architect/Engineer. Correct defects and conduct additional tests to demonstrate that the system conforms to contract specifications. Contractor shall provide two-way radios, personnel and test equipment required for conducting tests. Smoke detectors shall be tested using the manufacturer’s calibrated test method.
7. Manufacturer’s Field Service
   a. Manufacturer’s Representative
      1) Furnish the services of a factory-trained fire alarm system manufacturer’s representative or technician, experienced in the installation and operation of the type of system being provided, to supervise the installation, testing, including formal testing, adjustment of the system, and instruction to the facility personnel. Furnish names and phone numbers of the factory-trained fire alarm system representatives or technicians.

B. Training

   1. Equipment manufacturer shall provide 8 hours on site technical training to the owner or its representative (for two persons designated by Owner). Training shall allow for individual hands on programming, trouble-shooting and diagnostics exercises. Training shall occur within 2 months of system acceptance.

C. Adjustments

   1. Equipment manufacturer shall provide necessary subsequent custom reprogramming to modify and adjust operations and individual identification nomenclature to the owner satisfaction four months after final system acceptance and twelve months after system acceptance. Reprogramming is to be done at the job site and witnessed by the Authority Having Jurisdiction representative. Revision of as-built and record drawings shall be by the installing Contractor.

END OF SECTION
### 3.5 FIRE ALARM MATRIX

**FIRE ALARM MATRIX**

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<thead>
<tr>
<th>SYSTEM INPUTS</th>
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<td><strong>FIRE PROTECTION</strong></td>
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<td>-AUTOMATIC SPRINKLER WATERFLOW OTHER THAN GROUND FLOOR</td>
<td>ACTIVATES FIRE ALARM SPEAKERS AND STROBES FOR ALL FLOORS AND EXTERIOR ENTRY</td>
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<td>-AUTOMATIC SPRINKLER WATERFLOW GROUND FLOOR</td>
<td>ACTIVATES EXTERIOR BELL AND STROBE AT FIRE DEPARTMENT CONNECTION</td>
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<td>-MAIN FLOW SWITCH</td>
<td>RELEASE ELECTRIC LOCKS ON EXIT DISCHARGE DOORS</td>
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<td>-SPRINKLER TAMPER SWITCH</td>
<td>SHUT DOWN AFFECTED HVAC UNIT</td>
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<td><strong>SMOKE DETECTION</strong></td>
<td>ACTIVATES EXTERIOR BELL AND STROBE AT FIRE DEPARTMENT CONNECTION</td>
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<td>RELEASE MAGNETIC DOOR HOLDER CLOSING FIRE DOORS</td>
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<td>-ELEVATOR HOISTWAYS, MACHINE ROOMS</td>
<td>RELEASES ELEVATORS TO PRIMARY RECALL LEVEL</td>
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<td>-SMOKE DAMPER DUCT DETECTORS</td>
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<td>-ELEVATOR HOISTWAY AND MACHINE ROOM</td>
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<td>-MANUAL PULL STATIONS</td>
<td>ACTIVATES SUPERVISORY ALARM AT FACAP AND CAMPUS MONITOR STATION</td>
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<td>CLOSE FIRE/SMOKE DAMPER SERVING ASSOCIATED LAB AREA</td>
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<td>-FIRE ALARM AC POWER FAILURE</td>
<td>RELEASE ELECTRIC LOCKS ON INTERIOR EGRESS PATH DOORS</td>
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**END OF SECTION**
## Panel: AV1

### Details:
- **Type:** 208Y/120
- **Bus:** 100 Amps Copper
- **Main:** 100 Amp Main Bkr
- **Location:** AV CONTROL ROOM
- **Rating:** 3Phase,4Wire + Gnd

### Notes:
- A. PROVIDE GFCI CIRCUIT BREAKER.
- Options:
  - Feed-Thru Lugs

### Load Summary with Downstream Loads Included:

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### Conductors Colors (EC to Label in Panel):
- **PH A:** BLACK
- **PH B:** RED
- **PH C:** BLUE
- **PH N:** WHITE
- **PH G:** GREEN

### Conductors Connections:

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### Table of Connected Loads (Downstream Loads Included):

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### Summary:
- **Total Connected VA:** 34,860
- **Total Mains VA:** 27,680
- **Total Issue:** 77
### Panel AV2

**CU Boulder - Systems Biotech Bldg**

**M-E Engineers Inc.**

**Panel:** AV2

**Bus:** 100 Amps Copper

**Main:** 100 Amp Main Bkr

**Location:** AV CONTROL ROOM

**Notes:** A. PROVIDE GFCI CIRCUIT BREAKER. OPTIONS:

- **Date:** 09/20/13
- **Fed From:** AV1
- **Mounting:** Surface

**Connected (Downstream Loads Included) Load Summary With Downstream Loads Included**

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**Downstream Loads**

- **Recept:** 100%
- **Motor:** 100%
- **Lrgst Mtr:** 100%
- **Misc:** 100%
- **Kitchen:** 100%

**Conductor Colors (EC to Label in Panel)**

- **PH A:** Black
- **PH B:** Red
- **PH C:** Blue
- **PH N:** White
- **PH G:** Green

#### Table

<table>
<thead>
<tr>
<th>N</th>
<th>ID</th>
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<th>VA</th>
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<th>CKT</th>
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| A  | R  | WEST PLAZA RECEP     | 3640 | 2  | 50  | 7   | A  | 8  | 20  | 1  | 360 | CLASS RM A104 FLOOR BOX R |    |    |

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**ISSUE:**
### Panel Name: DP2
ETC 24 CIRCUIT DIMMER PANEL SCHEDULE
DRd12-24 UNISON DIMMER PANEL CHASSIS
120/208 - 3 PHASE, 4 WIRE
MLD WITH BUSS RATED UP TO 100A
14,000AIC
17’W x 30’H x 10’D

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**LOAD TYPE KEY**

- **INC** Incandescent
- **MLV** Magnetic Low Voltage
- **ELV** Electronic Low Voltage - Forward Phase Control Compatible Ballasts ONLY
- **2DFL** Two Wire Dimming Fluorescent (Advance Mark X, etc...)
- **3DFL** Three Wire Dimming Fluorescent (Advance Mark VII, etc...)
- **3DFLD** Three Wire Dimming Fluorescent Dim Leg
- **4DFL** Four Wire (Low Voltage) Dimming Fluorescent (Advance Mark VII, etc...)
- **ND** Non Load (Switched Load)
- **CC** Constant Circuit - Power Only - No Control
- **NEON** Neon
- **CCD** Cold Cathode

**Connected Load by Phase**

- Phase A: 6672 VA
- Phase B: 1308 VA
- Phase C: 4266 VA

**Total Connect Load:** 12246 VA

**Demand Factor:** 1.25

**Total Demand Load:** 15307.5 VA
### CONNECTED (Downstream Loads Included)

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### LOAD SUMMARY WITH DOWNSTREAM LOADS INCLUDED

**PHASE**
- **VA:** 8205 - 7800 - 7080
- **AMPS:** 68 - 65 - 59

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**CONDUCTOR COLORS (EC TO LABEL IN PANEL)**
- **PH:** Black
- **N:** White
- **G:** Green
- **B:** Red
- **C:** Blue

**TOTAL:** 23,085, 16,861, 47
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**CONDUCTOR COLORS (EC TO LABEL IN PANEL):**
- PH A: BLACK
- PH B: RED
- PH C: BLUE
- PH N: WHITE
- PH G: GREEN

**LOAD SUMMARY WITH DOWNSTREAM LOADS INCLUDED:**
- LIGHTING: 21,060 @ 125% 10,000 @ 75% 28 @ 50%
- RECEPT: 5,530 @ 100% 500 @ 100% 1 @ 100%
- MOTOR: 500 @ 25% 500 @ 50% 1 @ 100%
- LRGST MTR: 125 @ 100%
- MISC: 125 @ 100%
- KITCHEN: 125 @ 100%
- ELEC HEAT: 125 @ 100%

**TOTALS:**
- 21,560 @ 100% 16,155 @ 100% 45 @ 100%
# Electrical Panel Details

### Panel Information
- **Location:** CU Boulder - Systems Biotech Bldg
- **M-E Engineers Inc.:** CU Boulder Systems Biotech Bldg
- **PANEL:** LRP1B4
- **BUS:** 208Y/120
- **MAINS:** 125 Amps Copper M.L.O.
- **SECTION:** 1 OF 1
- **DATE:** 09/20/13
- **MOUNTING:** Recessed

### Notes and Options
- **OPTIONS:** 200% Neutral Bus
- **DATE:** 09/20/13
- **LOCATION:** LDP1SE
- **ISSUE:** N

### Circuit Details
- **ID:** DESCRIPTION
- **R:** CHBE TEACH LABS B171
- **V-A:** 720
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- **CKT:** A 2
- **FHC:** 30
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- **ID:** N

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- PHB: RED
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- PHN: WHITE
- PHG: GREEN

### Connected Loads
- **LIGHTING:** 100%
- **RECEPT:** 100%
- **MOTOR:** 100%
- **LRGST MTR:** 25%
- **MISC:** 100%
- **ELEC HEAT:** 100%

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CU Boulder - Systems Biotech Bldg | M-E Engineers Inc.  
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**PANEL:** | **LRP1B-5**
**BUS:** | 125 Amps Copper
**MAINS:** | M.L.O.
**SECTION:** | 1 OF 1
**LOCATION:** | 
**NOTES:** | OPTIONS:
208Y/120 | 
**DATE:** | 09/20/13
**FED FROM:** | LDP1SE
**MOUNTING:** | Recessed
**ISSUE:** | 

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**CONNECTED (Downstream Loads Included)**

**TOTALS**

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<th>FACTOR</th>
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**CONDUCTOR COLORS (EC TO LABEL IN PANEL)**

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**MSG2.xls**

**CONNECTED (Downstream Loads Included)**

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**CONDUCTOR COLORS (EC TO LABEL IN PANEL)**

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### Notes:
- **Options:** 200% Neutral Bus
- **Date:** 09/20/13
- **Fed From:** LDP1SE
- **Mounting:** Recessed
- **Issue:** N

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- **PH A:** BLACK
- **PH B:** RED
- **PH C:** BLUE
- **PH N:** WHITE
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### Connected (Downstream Loads Included)

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**CONDUCTOR COLORS (EC TO LABEL IN PANEL)**

- PH A: BLACK
- PH B: RED
- PH C: BLUE
- PH N: WHITE
- PH G: GREEN

**CONNECTED (Downstream Loads Included)**

**PHASE**

- A
- B
- C

**TOTALS**

- LIGHTING 125%
- RECEPT 100%
- MOTOR 100%
- LGST MTR 25%
- MISC 100%
- KITCHEN 100%
- ELEC HEAT 100%

**AMPS @ 208Y/120 VOLTS**

- 0 - 0 - 0

**AMP FACTORS**

- LIGHTING 125%
- RECEPT 100%
- MOTOR 100%
- LGST MTR 25%
- MISC 100%
- KITCHEN 100%
- ELEC HEAT 100%
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**CONDUCTOR COLORS (EC TO LABEL IN PANEL):**
- PH: A - BLACK
- PH: B - RED
- PH: C - BLUE
- PH: N - WHITE
- PH: G - GREEN

**LOAD SUMMARY WITH DOWNSTREAM LOADS INCLUDED:**
- PH: A - 100%
- PH: B - 100%
- PH: C - 100%
- PH: N - 100%
- PH: G - 100%

**DOWNSTREAM LOADS:**
- RECEPT: 100%
- MOTOR: 100%
- LRGST MTR: 25%
- MISC: 100%
- KITCHEN: 100%

**CONDUCTOR COLORS:**
- PH: A - BLACK
- PH: B - RED
- PH: C - BLUE
- PH: N - WHITE
- PH: G - GREEN

**TOTAL:**

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**CONNECTED (Downstream Loads Included)**

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**DOWNSTREAM LOADS**

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**CONDUCTOR COLORS (EC TO LABEL IN PANEL)**

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**LOAD SUMMARY WITH DOWNSTREAM LOADS INCLUDED**

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**CONDUCTOR COLORS (EC TO LABEL IN PANEL)**

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**CONNECTED (Downstream Loads Included)**

**PHASE**

- **A** - **B** - **C**

**TOTALS**

- **VA**
  - 5425 - 5050 - 4725
  - 14,200

**LOAD SUMMARY WITH DOWNSTREAM LOADS INCLUDED**

**VA**

- 5425 - 5050 - 4725
- 14,200

**FACTOR**

- LIGHTING 125%
- RECEPT 10,800 100%
- MISC 2,000 100%
- KITCHEN 100%

**AMPS @ 208Y/120 VOLTS**

- 10,000 10,000 28
- 39

**CONDUCTOR COLORS (EC TO LABEL IN PANEL)**

- **PH**
  - A BLACK
  - B RED
  - C BLUE
  - N WHITE
  - G GREEN

**TOTAL**

- 14,200
- 13,938
- 39
### Panel Specifications

**CU Boulder - Systems Biotech Bldg**

**M-E Engineers Inc.**

**PANEL:** SBRP1B-2

**208Y/120**

**3Phase,4Wire + Gnd**

**BUS:** 200 Amps Copper

**MAINS:** 200 Amp Main Bkr

**LOCATION:**

**NOTES:**

**OPTIONS:**

**DATE:** 09/20/13

**FED FROM:** SBRP1B-1

**MOUNTING:** Recessed

**ISSUE:**

---

### Electrical Load Summary

#### Connected (Downstream Loads Included)

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#### Load Summary with Downstream Loads Included

- **VA:** 200 Amps
- **AMPS:** 200 Amps

#### Downstream Loads

- **RECEPT:** 100%
- **MOTOR:** 100%
- **LRGST MTR:** 25%
- **MISC:** 100%
- **KITCHEN:** 100%

#### Conductor Colors (EC to Label in Panel)

- **PH A:** BLACK
- **PH B:** RED
- **PH C:** BLUE
- **PH N:** WHITE
- **PH G:** GREEN

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**NOTE:**

- **MSG2.xls**

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**CONNECTED (Downstream Loads Included)**

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**LOADS AT 208Y/120 VOLTS**

- **VA:** 200 Amps
- **AMPS:** 200 Amps