SECTION 15955
{23 0905}
BAS SOFTWARE AND PROGRAMMING

PART I. 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 15010 - Basic Mechanical Requirements
C. Section 15950 - Building Automation System (BAS) General
D. Section 23 0900 – Building Automation System (BAS) General
E. Section 15951 - BAS Basic Materials, Interface Devices, and Sensors
F. Section 23 0913 – BAS Basic Materials, Interface Devices, and Sensors
G. Section 15952 - BAS Operator Interfaces
H. Section 23 0902 - BAS Operator Interfaces
I. Section 15953 - BAS Field Panels
J. Section 23 0903 - BAS Field Panels
K. Section 15954 - BAS Communications Devices
L. Section 23 0904 - BAS Communication Devices
M. Section 15958 - Sequences of Operation
N. Section 23 0993 - Sequences of Operation
O. Section 15959 - BAS Commissioning
P. 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 15950 {23 0900} - Building Automation System (BAS) for general
requirements
C. Refer to 15958 \{23 0993\} - 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 15950 \{23 0900\} - Building Automation System (BAS) General for further requirements.

PART II. 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 15954) with the restrictions/exceptions per application provided in Section 15953:

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 15953 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 15953 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 re-transmission 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 15958 {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 BCs 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.

**Include the following only if you are trying to mandate strict BACnet Interoperability.**

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**

*Edit the following based on how operators will remotely connect*

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 III. 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
      c) All unrestricted system capabilities including all network management
         functions.

   2. Level 2: (System Engineers)
      a) Level 3 capabilities
      b) Configure system software
      c) Modify control unit programs
      d) Modify graphic software
      e) Essentially unrestricted except for viewing or modifying 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.

END OF SECTION 15955 {23 0905}