PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Building wire.
   2. Remote control and signal cable.
   3. Wiring connections and terminations.
   4. Modular wiring systems.

B. Related Sections:
   1. Section 16110 - Raceways

1.02 REFERENCES

A. Specify Underwriters Laboratories (UL) listed equipment, assemblies and materials.

B. Where appropriate, refer to current NEMA Standards for material ratings.


PART 2 PRODUCTS

2.01 BUILDING WIRE

A. Thermoplastic - Insulated Wire:
   1. Types THW, THHN, THWN; rating 600V.

B. Rubber - Insulated Building Wire:
   1. Types RH, RHW, RHH, XHHW; rating 600V.

C. Conducted Material:
   1. Conductors #10 AWG and larger, stranded copper.
   2. Conductors smaller than #10 AWG, solid copper.

D. Control Wire:
   1. Stranded copper with 600V insulation.

2.02 REMOTE CONTROL AND SIGNAL CABLE

A. Class 1, 2, or 3:
1. Copper conductor, 300V insulation, rated 60°C, covered with PVC jacket.

2. All control and signal cables shall be in conduit.

2.03 MODULAR WIRING SYSTEMS

A. Not allowed.

2.04 TERMINATION

A. Splices and taps are to carry full ampacity of conductors without perceptible temperature rise.

PART 3 EXECUTION

3.01 GENERAL WIRING METHODS

A. Device removal - in multi-wire branch circuit - where a circuit extends through a receptacle, it shall be a requirement that all conductors shall be pigtailed so downstream load does not go through receptacles.

B. Where harmonic currents exist on circuits supplying electric discharge lighting, data processing or similar equipment, a full sized neutral shall be provided for each single phase circuit, and an oversized neutral may be required for each multi-wire circuit.

C. Wire Sizing:

1. Minimum wire size of #12 AWG for power and lighting circuits.

2. Minimum wire size #14 AWG for control circuits.

3. For 20 ampere 120V circuits longer than 75’, specify #10 AWG conductors.

4. For 20 ampere 277V circuits longer than 150’, specify #10 AWG conductors.

5. For circuit amperes other than 20 ampere and for distances greater than listed above, calculate voltage drop and size conductors for maximum 3% voltage drop.

D. Wire Color Coding:

1. Color code wires for building voltage classes as follows:

<table>
<thead>
<tr>
<th>120/208V-3Ø</th>
<th>15,000 Volts</th>
<th>277/480V-3Ø</th>
</tr>
</thead>
<tbody>
<tr>
<td>ØA - Black</td>
<td>ØA - Black</td>
<td>ØA - Brown</td>
</tr>
<tr>
<td>ØB - Red</td>
<td>ØB - Red</td>
<td>ØB - Orange</td>
</tr>
<tr>
<td>ØC - Blue</td>
<td>ØC - Blue</td>
<td>ØC - Yellow</td>
</tr>
<tr>
<td>Neutral - White</td>
<td>Neutral - White</td>
<td>Neutral - Gray</td>
</tr>
<tr>
<td>Ground - Green</td>
<td>Ground - Green</td>
<td>Ground - Green</td>
</tr>
</tbody>
</table>

E. Parallel Conductors:

1. Specify that parallel conductor feeders be installed so that all runs are of identical equal length.
F. Insulation Ratings:
   1. All conductors shall be specified 600V rated.
   2. Insulation types specified shall conform to NEC requirements for temperature, moisture, and mechanical environmental conditions.

G. AU multiwire circuits require dedicated neutrals. No multi branch circuit breakers are permitted.

3.02 WIRING INSTALLATION IN RACEWAYS
A. Wire Pulling:
   1. Require all conductors to be pulled into conduit at the same time.
   2. Specify UL listed wire pulling lubricant.
   3. Require conduits to be swabbed clean before wire is pulled in.
B. Length of conductors at receptacles, junction, and switches at least 6” of free conductor shall be left at each outlet, junction and switches for splices or connection of fixtures or devices.

3.03 CABLE INSTALLATION
A. Cable Protection:
   1. Provide protection for cables where subject to mechanical damage.

3.04 WIRING CONNECTIONS AND TERMINATIONS
A. General Requirements:
   1. Specify that conductors may be spliced only in accessible junction boxes or wireways.
   2. Require that wires be thoroughly cleaned before installing lugs or connectors.
   3. Specify a grounding conductor(s) in all branch circuit raceways.

3.05 QUALITY CONTROL
A. Feeders:
   1. Require continuity and insulation (meggar) resistance testing of all feeders. Minimum four (4) meg.

END OF SECTION 16120
March 25, 2010

University of Colorado
ENVD – 18-90
319 UCB
Boulder, CO 80309-0319
Attn: Derek Scott

Derek,

I appreciate being able to meet with you and Tim last week. I have worked very closely with the University of Colorado for the past 15 years regarding your 15kV cable. I have also worked with your consultants and contractors on your projects.

A problem that always arises for the contractors is the availability of cable. Over the years, lead-times have been anywhere from 8 weeks to 28 weeks. Manufacturers also have a minimum manufacturing quantity. The reason for the problems with availability and minimum manufacturing quantity is because of your specification. Your specification is a great spec as far as engineering goes; however, it is my opinion that it is overkill.

I would like to recommend that you specify a standard cable that is used by the electric utility companies across the country. The two differences are copper to aluminum and the cable tray rated jacket be changed to a polyethylene jacket that is designed for conduit installation.

If you have a project that requires cable to be installed in cable tray, you could have a separate paragraph in the spec stating “Jacket must be rated for cable tray use” – PVC – Flame Retardant Jacket.

The 15kV cables that utilities use across the country are probably 95% aluminum conductor. The 5% copper is probably 1000 KCMIL which is used to get a little more ampacity at the largest conductor size.

By standardizing on the aluminum conductor that utilities use, you get the benefit of large manufacturing quantities which lowers the cost. For example, we manufacture 1/0 800,000 feet at a time. When we make cable for you, we only make what you need.

Availability is another issue. We have over $1,000,000 of this cable in stock in Brighton, Co. No more having the contractor complaining about not being able to get cable in time for the job. Okonite has a lot of faith in this product. We have a written 40-year warranty, which I have attached.

I know in this day and age the University of Colorado is constantly under financial pressure. One of the best parts of my proposal is the HUGE cost savings. Depending on what conductor size you compare, the savings could be 25% - 50%.

I am 100% confident that my recommendation will work for the University of Colorado. I will be happy to answer any questions you might have regarding this subject.

Marlin Copeman
District Manager

Cc: Timothy Geck
University of Colorado Specification

Copper Conductor – 220 MIL EPR Insulation – Bare Copper Wire Concentric Neutral – Cable Tray Rated PVC Jacket.

**Price Comparisons**

<table>
<thead>
<tr>
<th>Size</th>
<th>Price/FT</th>
</tr>
</thead>
<tbody>
<tr>
<td>2/0</td>
<td>$5.00</td>
</tr>
<tr>
<td>4/0</td>
<td>$5.80</td>
</tr>
<tr>
<td>350</td>
<td>$7.80</td>
</tr>
<tr>
<td>500</td>
<td>$12.00</td>
</tr>
</tbody>
</table>

Cable that is used by XCEL Energy and the other 22 Electric Utilities in Colorado is basically the same construction that you use, except aluminum conductor and a polyethylene outer jacket.

<table>
<thead>
<tr>
<th>Size</th>
<th>Price/FT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/0</td>
<td>$2.54</td>
</tr>
<tr>
<td>4/0</td>
<td>$2.67</td>
</tr>
<tr>
<td>350</td>
<td>$3.98</td>
</tr>
<tr>
<td>500</td>
<td>$5.22</td>
</tr>
<tr>
<td>750</td>
<td>$7.12</td>
</tr>
</tbody>
</table>

**Amperage Comparisons**

<table>
<thead>
<tr>
<th>Copper Conductor</th>
<th>Aluminum Conductor</th>
</tr>
</thead>
<tbody>
<tr>
<td>2/0</td>
<td>1/0</td>
</tr>
<tr>
<td>245 Amps</td>
<td>165 Amps</td>
</tr>
<tr>
<td>4/0</td>
<td>3/0</td>
</tr>
<tr>
<td>315 Amps</td>
<td>245 Amps</td>
</tr>
<tr>
<td>350</td>
<td>350</td>
</tr>
<tr>
<td>415 Amps</td>
<td>330 Amps</td>
</tr>
<tr>
<td>500</td>
<td>400 Amps</td>
</tr>
<tr>
<td>500 Amps</td>
<td>490 Amps</td>
</tr>
</tbody>
</table>

These ratings are 100% load factor. Your load factors are probably 75%, which means you can actually carry more current on the cables.

**Conduit Comparisons**

<table>
<thead>
<tr>
<th>Copper Conductor</th>
<th>Aluminum Conductor</th>
</tr>
</thead>
<tbody>
<tr>
<td>2/0</td>
<td>1/0</td>
</tr>
<tr>
<td>1.15&quot; OD</td>
<td>1.15&quot; OD</td>
</tr>
<tr>
<td>4&quot; Conduit</td>
<td>4&quot; Conduit</td>
</tr>
<tr>
<td>4/0</td>
<td>3/0</td>
</tr>
<tr>
<td>1.26&quot; OD</td>
<td>1.25&quot; OD</td>
</tr>
<tr>
<td>4&quot; Conduit</td>
<td>4&quot; Conduit</td>
</tr>
<tr>
<td>350</td>
<td>5/0</td>
</tr>
<tr>
<td>1.45&quot; OD</td>
<td>*1.50&quot; OD</td>
</tr>
<tr>
<td>4&quot; Conduit</td>
<td>5&quot; Conduit</td>
</tr>
<tr>
<td>500</td>
<td>5/0</td>
</tr>
<tr>
<td>1.61&quot; OD</td>
<td>1.72&quot; OD</td>
</tr>
<tr>
<td>5&quot; Conduit</td>
<td>5&quot; Conduit</td>
</tr>
</tbody>
</table>

*We could reduce the jacket thickness from 50 mils to 40 mils and then it would fit into a 4" conduit.*
Okoguard® URO-J

15kV Underground Primary Distribution Cable-Jacketed
Red Identification Stripes
Filled Strand Aluminum Conductor/105°C Rating
100% and 133% Insulation Levels

Insulation
Okoguard is Okonite's registered trade name for its exclusive ethylene-propylene rubber (EPR) based, thermosetting compound, whose optimum balance of electrical and physical properties is unequaled in other solid dielectrics. Okoguard insulation, with the distinctive red color and a totally integrated EPR system, provides the optimum balance of electrical and physical properties for long, problem-free service.

The triple tandem extrusion of the screens with the insulation provides optimum electrical characteristics.

The compressed conductors are filled with water swellable powder. This construction slows the migration of water through the strands in the event of a mechanical dig-in followed by external exposure to water.

An insulation screen of ethylene-propylene rubber is extruded over the insulation. The copper concentric wires are uniformly spaced around the insulation screen. The overall polyethylene jacket provides protection against mechanical damage and corrosion.

Product identification is provided through the use of three red stripes placed 120° apart in the black jacket, with an NESC lightning bolt.

Applications
Okoguard URO-J cables provide maximum circuit longevity in underground residential distribution systems. They can be buried directly or installed in underground ducts or conduits.

Specifications
Central Conductor: Aluminum per ASTM B-609, Class B stranded per B-231.
Filled Strand: Water swellable powder meets or exceeds ICEA T-31-610 water penetration resistance and ANSI/NEMA class A connectorability requirements.
Conductor Screen: Extruded semiconducting ethylene-propylene rubber meets or exceeds the requirements of ICEA S-94-649 and AEIC CS8.
Insulation: Extruded Okoguard meets or exceeds the requirements of ICEA S-94-649 and AEIC CS8.
Insulation Screen: Extruded semiconducting ethylene-propylene rubber meets or exceeds the requirements of ICEA S-94-649 and AEIC CS8.
WARRANTY FOR OKONITE CABLES

The Okonite Company warrants that the cable furnished under this contract is of first-class material and workmanship and that the cable is free from defects in materials or workmanship for a period of forty (40) years from the date of shipment if installed, terminated, and operated within acceptable industry practices and standards. In the unlikely event the cable is found to be defective in either material or workmanship, the Okonite Company agrees to repair or provide replacement cable for the defective length of cable during the 40-Year Warranty. This Warranty is based upon the cable being installed and field tested in accordance with The Okonite Company’s accepted testing and procedures as set forth in the latest edition of our Engineering Data Bulletin (EHB).

Additionally, in the event of a failure due to defects in materials or workmanship, The Okonite Company will also extend credit for attendant labor cost for the replacement or repair of any defective cable during the first twenty (20) years of service. In the event replacement cable is necessary, labor costs will be reimbursed in accordance with the following:

First 20 years - Cable replacement, plus an amount not to exceed 200% of the original cable price for the length involved, or three thousand dollars ($3,000.00) whichever is greater.

21 to 40 years - Replacement only of the length of cable involved, unless there is a proven defect in the compound insulation system. In that case, the consideration stated above for the first 20 years will also apply.

No other warranty, either written or implied, and no other remedy afforded by law, applies to Okonite cable.

APPROVED:

V. A. Viggiano 9/5/06  
V. A. Viggiano  
Chairman

A. C. Coppola 9/5/06  
A. C. Coppola  
President