NEORSD

ELECTRICAL STANDARDS AND CONVENTIONS

Revision 2.1  Date: 9/29/2017
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## Revision History

<table>
<thead>
<tr>
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<td>NEORSD</td>
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<td>PSIM</td>
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<tr>
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<td>P. McGuire</td>
<td>Section 4, <em>Instrumentation and Network Cable</em></td>
<td>Removed DeviceNet cable specification from Section 4 and added note to refer to Section 9, <em>DeviceNet Networks</em></td>
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<td>Y = Intermediate modification to any section of the document. Typically a clarification to an existing section. This level of change requires a review and approval by subject matter experts.</td>
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<td>Z = Minor change to a proposed revision. Example: 1.1.0 is submitted for review, and a spelling error is caught. The document is revised up to 1.1.1 and continued through the review cycle. It is not necessary to go back to previous subject matter experts for a second review.</td>
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Electrical Standards and Conventions

Section 1 - Conduit System

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This section provides the detailed requirements for conduit systems. The types of conduit and appurtenances detailed include the following:

- Aluminum conduit and fittings for all exposed conduit runs.
- PVC coated rigid conduit and fittings for exposed conduit runs in areas that contain an environment that is corrosive to aluminum.
- Schedule 80 PVC conduit and fittings for buried and concrete encased duct bank runs.
- Fiberglass conduit and fittings for transitions from concrete duct bank to exposed rigid conduit.
- Flexible metallic conduit and fittings.
- Sealing fittings.
- Expansion fittings.
- Outlet boxes.
- Pull and junction boxes.

Section 1.A - Detailed Specifications

1. Aluminum Conduit, Elbows and Couplings:
   a. Material: Rigid, heavy wall 6063 alloy, temper T-1 aluminum, smooth interior, tapered threads and carefully reamed ends; ¾ inch NPS minimum size.
   b. For all exposed runs.
   c. Joints: Threaded with lubricant by Burndy Pentrox or approved equal.
   d. Manufacturer: Provide aluminum conduit from one of the following:
      i. V.A.W. of America, Inc.
      ii. Anamet Inc.
      iii. Or Approved Equal

2. Aluminum Conduit Fittings and Outlet Bodies:
   a. Material and construction: Cast copper-free aluminum bodies and covers with stainless steel screws. All units are to have gaskets and be watertight. Gaskets shall be neoprene. Improvised gaskets and cork gaskets are not acceptable. All units are to be the threaded type with five full threads. Material is to conform to ANSI and be listed by UL. The use of ‘LB’ fittings shall be avoided and type ‘LBD’ fittings applied wherever the use of fittings is unavoidable.
   b. Manufacturer: Provide aluminum conduit fittings and outlet bodies from one of the following:
      i. Crouse-Hinds Co.
3. PVC Coated Rigid Steel Conduit, Elbows and Couplings:
   a. Material: Rigid, heavy wall, mild steel, hot dip galvanized inside and out, smooth interior, tapered threads and carefully reamed ends; ¾” NPS minimum size.
   b. PVC Coating: PVC coating to be bonded to the outer surface of the galvanized conduit. Ensure that the bond between the coating and the conduit surface is greater than the tensile strength of the coating. Provide the inside surfaces and threads of the conduit with a 2-mil urethane coating. Provide a PVC coating thickness of not less than 40 mils.
   c. Manufacturers:
      i. Robroy Industries
      ii. Thomas and Betts
      iii. Or Approved Equal

4. Non-metallic conduit:
   a. PVC Plastic:
      i. Material: Schedule 80 PVC plastic, NEMA Type EPC-80-PVD, 90 deg. C rated, conforming to UL No. 651.
      ii. For buried and concrete encased ductbank runs
      iii. Manufacturer: Provide non-metallic conduit from one of the following:
            1. Amoco Chemicals Corporation.
            2. Carlon, Division of Indian Head, Incorporated.
            3. Or Approved Equal.
   b. Fiberglass:
      i. Material: Fiberglass reinforced epoxy manufactured using a filament winding process. Resin systems shall be epoxy with no fillers. Glass used shall be E-type. Nominal wall thickness of ¼ inch. Rated for Class 1 Div. 2 applications.
      ii. For a transition piece from concrete encased ductbanks to exposed conduit systems as they stub-up through a concrete slab.
      iii. Manufacturer: Provide fiberglass conduit from one of the following:
            1. Champion Fiberglass.
            2. Or Approved Equal.
   c. Non-metallic Fittings: Form elbows, bodies, terminations, expansions and fasteners of same material and manufacturer as base conduit. Provide cement by same manufacturer as base conduit.

5. Flexible Conduit (non-hazardous areas):
   a. Material: Flexible galvanized steel core with smooth, abrasion-resistant, liquid-tight, polyvinyl chloride cover. Continuous copper ground built in for sizes ¾ inch through 1-¼ inch. Material shall be UL listed. An exterior bonding strap will be installed on all installations 1-1/2” or greater.
   b. Product and Manufacturer: Provide conduit from one of the following:
      i. Sealtite UA by Anaconda Metal Hose Division, Anaconda American Brass Company.
      ii. Liquatite Type L.A. by Electric-Flex Company.
iii. Or Approved Equal.

6. Flexible Conduit Fittings:
   a. Material and Construction: Malleable iron with cadmium finish. Fittings shall adapt the conduit to standard threaded connections, shall have an inside diameter not less than that of the corresponding standard conduit size and shall be UL listed. Fittings shall be vibration proof and weather proof with captive O-ring seal.
   b. Manufacturer: Provide flexible conduit from one of the following:
      i. Crouse-Hinds Company.
      ii. Appleton Electric Company.
      iii. Or Approved Equal.

7. Expansion Fittings:
   a. Material and Construction: Copper free aluminum or stainless steel body, stainless steel clamps and tinned copper braid bonding jumper. Fitting to be watertight, corrosion-resistant UL listed and compatible with the conduit system.
   b. Product and Manufacturer: Provide expansion fittings from one of the following:
      i. Type AX for expansion only by O/Z Gedney Company.
      ii. Type XJ for expansion only by Crouse Hinds Company.
      iii. Or Approved Equal.

8. Device Boxes and Outlet Boxes:
   a. Non-Hazardous and/or Non-Corrosive Areas:
      i. Material:
         1. Flush Mounted: Cast copper-free aluminum.
         2. Surface Mounted: Cast copper-free aluminum.
      ii. Device Cover Plates:
         1. Stainless steel Type 302 alloy for indoor finished areas.
         2. Stainless steel screws and hardware.
         3. Neoprene gaskets. Improvised or cork gaskets are not acceptable.
         4. Covers and gaskets are to be by the same manufacturer as the box.
      iii. Manufacturers:
         1. Appleton Electric Company.
         3. Or Approved Equal.

9. Junction and Pull Boxes (12” x 12” and smaller):
   a. Materials and Construction:
      i. NEMA 4X, 316 stainless steel or NEMA 4X, fiberglass bodies and covers.
      ii. Neoprene gaskets. Improvised gaskets and cork gaskets are not acceptable.
      iii. Stainless steel cover screws.
      iv. External mounting lugs.
      v. Boxes shall be provided with no knockouts.
      vi. Boxes shall be constructed with welded seams and covers.
      vii. Boxes where conduits enter a building below grade shall have ½ inch drain hole with a petcock type fitting attached for ½ inch
tubing drain line. Provide ½ inch drain line and fittings of polyethylene tubing to nearest drain trench or sump.

b. Manufacturer: Provide pull and junction boxes of one of the following:
   i. Hoffman
   ii. Saginaw Control & Engineering
   iii. RobRoy
   iv. Or approved equal.

10. Junction and Pull Boxes (larger than 12” x 12”):
   a. Materials and Construction:
      i. NEMA 4X, 316 stainless steel or NEMA 4X, fiberglass bodies and covers.
      ii. Neoprene gaskets. Improvised gaskets and cork gaskets are not acceptable.
      iii. Stainless steel cover screws.
      iv. External mounting lugs.
      v. Boxes shall be provided with no knockouts.
      vi. Boxes shall be constructed with welded seams and covers.
      vii. Boxes where conduits enter a building below grade shall have ½ inch drain hole with a petcock type fitting attached for ½ inch tubing drain line. Provide ½ inch drain line and fittings of polyethylene tubing to nearest drain trench or sump.
      viii. Boxes larger than 24” x 24” to have hinged doors. All clamps shall be stainless steel with stainless steel screws.
   b. Manufacturer: Provide pull and junction boxes of one of the following:
      i. Hoffman
      ii. Saginaw Control & Engineering
      iii. RobRoy
      iv. Or approved equal.

11. Conduit Hubs:
   a. Material: Threaded conduit hub, vibration proof, weather proof with captive O-ring seal, copper-free aluminum with insulated throat.
   b. Use: Provide for all conduit terminations to boxes, cabinets and other enclosures.
   c. Manufacturer: Provide material manufactured by Myers Electrical Products Company or approved equal.

12. Thruwall Seals:
   a. Material:
      i. Interior Walls: Use PVC sleeves with approved fire stop materials
      ii. Exterior Walls: Use Link Seals with stainless steel hardware, if the wall is 8” thick or greater, use (2) sets of link seals
         1. CMU construction: Use PVC sleeve
         2. Solid concrete construction: No sleeve is required
   b. Or approved equal.

13. Supports:
   a. Rigidly support conduits by clamps, hangers or strut channels. Standard support strut shall be 1-5/8” wide x 12 gage (.105”, minimum). Support
strut used in exterior locations shall be 316 stainless steel. Support strut used in interior locations shall be either aluminum or fiberglass.

b. Support single conduits by means of one-hole pipe clamps in combination with one-screw back plates, to raise conduits from the support surface. Support multiple runs of conduits on trapeze type hangers with 316 stainless steel threaded hanger rods. Rods shall be not less than 3/8-inch diameter.

c. All support hardware (nuts, bolts, washers, etc.) shall be manufactured from 316 stainless steel.

d. For freestanding supports, provide doublewide strut with post base anchored to floor. Support strut used in exterior locations shall be 316 stainless steel. Support strut used in interior locations shall be either aluminum or fiberglass.

Section 1.B - Installation Details

This section does not contain all installation details for the equipment/system shown, only those that are required by the NEORSD. These details may exceed those required by the equipment manufacturer or local codes.

1. Exposed Conduit Installation:
   a. All fastening hardware shall be stainless steel.
   b. Provide aluminum conduit racks of suitable width, length and height and arranged to suit field conditions. Provide support at every eight feet minimum.
   c. Maintain 6 inches from hot fluid lines and 1/4 inch from walls using non-metallic spacers.
   d. All CMU through-wall penetrations shall be sleeved with PVC conduit.
   e. All interior wall through-wall penetrations shall be sleeved with PVC conduit.

2. Conduit Embedded in Concrete Installation:
   a. Separation: Three times outer diameter of larger conduit center to center.
   b. Minimum distance from edge of slab:
      i. With no crisscrossing of conduit, three times outer diameter of conduit.
      ii. With crisscrossing of conduits, four times outer diameter of largest conduit.
   c. Run conduit in center of slab.

3. Underground Conduit Installation:
   a. Duct banks shall be constructed using a 3000 psi concrete mix.
   b. All conduits installed in duct banks shall be Schedule 80 PVC.
   c. Assemble duct banks using non-magnetic saddles, spacers and separators. Separators are to be positioned to provide 3-inch minimum concrete separation between the outer surfaces of the ducts.
   d. Manufacturer:
      i. Underground Devices Inc.
      ii. Or approved equal.
   e. Provide a 3-inch minimum concrete covering on both sides, top and bottom of concrete envelopes around conduits. Add red dye to concrete used for
envelopes for easy identification during subsequent excavation. Dye is to be mixed inside the concrete truck. Pricing shall include appropriate truck clean-out.

f. Make bends with sweeps of not less than 48-inch radius or 5 degree angle couplings.

g. Make a transition from non-metallic to PVC coated rigid steel or fiberglass conduit where duct banks enter structures or turn upward for continuation above grade.

h. Reinforce duct banks:
   i. Reinforce with No. 4 longitudinal steel bars (minimum) placed at each corner and along each face at a maximum parallel spacing of 18-inches on centers, and No. 3 tie-bars transversely placed at 18-inch maximum longitudinal intervals.
   ii. Maintain a maximum clearance of one inch from bars to the edge of the concrete encasement.
   iii. An exception shall be when 1 or 2 conduits only make up the duct bank. In this case a cage using 6”x6” road mesh will be acceptable as reinforcement.

i. Where ducts enter structures such as manholes, handholes, pullboxes, or buildings, terminate the ducts in suitable end bells, insulated bushings or couplings on PVC coated rigid steel or fiberglass conduits.

j. Slope duct runs for drainage away from buildings with a slope of approximately 3 inches per 100 feet.

k. Install a bare stranded copper duct bank ground in each duct bank envelope. Make ground electrically continuous throughout the entire duct bank system and connect to ground buses and to PVC coated rigid steel or fiberglass conduit extensions of underground duct system.

l. Install a detectable warning ribbon approximately 12 inches above all underground duct banks carrying cables of 480 volts and higher. The identifying ribbon shall be a PVC tape, 2-inches wide, red color, permanently imprinted with "CAUTION BURIED ELECTRIC LINE BELOW" in black letters.

4. Empty Conduits:
   a. Install nylon pull wire in each empty conduit and cap conduits not terminating in boxes with permanent fittings designed for the purpose. Nylon pull line shall have a minimum 500 lb. tensile strength.
   b. Identify each empty conduit with a durable tag showing the conduit number.
   c. Install appropriate conduit caps with line attachment provisions.

5. Conduit Terminations:
   a. Install insulated bushings on conduits entering boxes or cabinets, except on threaded hub type boxes.
   b. Provide locknuts on both inside and outside of enclosure for grounding. If hubs are not used, provide locknut and sealing O-ring on outside of enclosure with a bushing and locknut on the inside.
   c. Bushings are not to be used in lieu of locknuts.
   d. Grounding bushings shall be installed on all metallic conduits.
6. Corrosion Protection:
   a. In concrete slabs or floors, provide a four-inch high chamfered curb
      extending two inches from the outer surface of the conduit penetrating the
      floor, to prevent corrosion.
   b. Terminate conduit stub-ups in couplings, slightly above the finished
      concrete curb. In exposed traffic areas transition PVC conduit to a PVC-
      coated rigid steel or fiberglass conduit stub-up.
   c. Use plastic/nylon ¼” minimum spacers to prevent aluminum in contact
      with masonry or concrete.

7. Non-metallic Conduit Installation:
   a. During installation provide expansion fittings for expansion and
      contraction to compensate for temperature variations. Expansion fittings
      shall be watertight and of the type suitable for direct burial.
   b. Make transition to PVC coated rigid steel or fiberglass conduit before
      making turn up to enclosures.
   c. Provide watertight expansion/deflection fittings at all wall and floor
      penetrations of all buildings and equipment concrete pads.
   d. Minimum spacing for supports shall be 5’

8. Conduit Labeling System:
   a. All conduits shall be labeled using self-adhesive Brady B-580 or B-595
      vinyl film conduit & voltage markers, color coded, minimize size: 1-1/8" x
      4-1/2" with a 7/8" character height, as manufactured by the W.H. Brady
      Co. or approved equal.
      i. Medium Voltage Power conduits (13.2KVAC, 4,160VAC) – Red
      ii. Low Voltage Power conduits (480VAC to 120VAC) – Orange
      iii. Control/Instrumentation (Control wires regardless of voltage)
           - Blue
      iv. Intrinsically Safe conduits – Light Blue
      v. Data & Communications (telephone, Devicenet, Ethernet, CCTV)
         – White
      vi. Fiber Optic - Yellow
   b. Installation:
      i. All conduit including lighting and receptacle circuits shall be provided
         with unique conduit labels unless otherwise specified.
      ii. Flexible conduit shall not be labeled.
      iii. Conduit labels shall convey the following information:
          1. Conduit Number: Alphanumeric, format provided by NEORSD.
          2. Markers/purpose shall be provided to convey Conduit Purpose, with
             identifier prefix, as applicable, from the following list. All voltages are
             AC unless otherwise identified:
             a. M (13,200 V/4160 V Power)
             b. MT (13,200 V/4160 V Power Cable Tray)
             c. P (480 V/277 V Power)
             d. PT (480 V/277 V Power Cable Tray)
             e. L (120 V Power or 24V AC Power)
             f. C (120 V Control or 24V AC Control)
             g. PC (480 V/277 V Power and 120 V Control Combined)
h. S   (120 V or 24 V DC Status)
i. SC  (120 V Status and 120 V Control Combined)
j. IN  (4 to 20 mA DC Instrumentation)
k. H   (24 V DC Control)
l. IH  (4 to 20 mA DC Instrumentation and 24 V DC Control Combined)
m. IS  (Intrinsically Safe)
n. D   (Data and communications such as WAN, LAN, PLC, DeviceNet, Modbus, telephone, and similar)
o. SH  (24 V DC Status and 24 V DC Control Combined)
p. FA  (Fire Alarm)
q. E   (Empty conduit)

iv. Conduit Naming Convention:

P- 001 = Conduit tag P-001
↑ ↑ Conduit label color - Orange
Marker/Purpose, Unique conduit identifier
(from 8.b.iii.2 list) (3 digit)
(480V/277V Power)+(Conduit 001)

Per NEC Art. 504, Intrinsically Safe conduits must be labeled “Intrinsic Safety Wiring”. Example:

IS-001 INTRINSIC SAFETY WIRING
Conduit label color – Light Blue

v. Conduit labels shall be installed at the following locations:
1. Where conduit enters and exits walls, ceilings, floors or slabs.
2. Where conduit enters or exits boxes, cabinets, consoles, panels or enclosures, except conduit bodies used for pull boxes.
3. At intervals of not more than 50 feet along the length of the conduit.
4. Per NEC Art. 504, Intrinsically Safe conduits at intervals of not more than 25 feet along the length of the conduit.

vi. Conduit labels shall be oriented so as to be readable.

vii. All conduits including lighting and receptacle shall have a unique label.
Multi-circuit conduits shall change when circuits are split at a pullbox or TEE fitting.

Flexible Conduit Installation:

   c. Limit flexible conduit length to six feet maximum.

9. Installation of Expansion Fittings:
   a. Install expansion/deflection fittings where conduits cross structural expansion joints.
   b. Exterior exposed conduits, every 200’ maximum

10. Installation of Outlet and Device Boxes:
   a. To avoid mounting boxes directly on brick, masonry or concrete walls,
provide suitable 1/2-inch non-metallic spacers to prevent mounting back of box directly against wall.

b. Leave no open conduit holes in boxes.

c. Outlet boxes/bodies to have external mounting provisions. Back drilling will not be permitted.

d. Label each cable and/or wire in boxes and identify with durable tag as to what circuit the cable and/or wire is connected.

11. Installation of Pull and Junction Boxes:

a. Securely fasten boxes to walls or other structural surfaces with ½” spacing on which they are mounted. Provide independent supports where no walls or other structural surface exists. Interior supports are to be aluminum while exterior locations shall be stainless steel or fiberglass.

b. Install pull boxes in runs so that there are no more than (3) 90 degree bends, runs exceeding 200 feet and where required to conform with the National Electrical Code.

c. Provide terminal blocks in junction boxes where cable terminations or splices are required. Terminal blocks are to be sized per the National Electrical Code.

d. Ceiling mounted enclosures are not to be permitted without the expressed written consent of the Engineer.

12. Pull and Junction Box Labeling System:

a. All pull and junction boxes shall be labeled with nameplates. Nameplates shall be engraved laminated plastic with black letters and numerals engraved on a white background and shall have beveled edges. Nameplates shall be engraved with characters 1" high on boxes larger than 12" x 12" and 1/2" high on boxes smaller than 12" x 12". Nominal size of nameplates shall be 2"x 6", except where larger sizes are required to contain all data required or where smaller is necessary to fit on the face size of a smaller junction box. Attach nameplates using stainless steel machine screws, drilled and tapped with thread seal, in order to maintain the NEMA rating of the enclosure.

13. Spare Conductor Requirements:

a. For conduit runs that are entirely within NEC unclassified (non-hazardous) areas, provide 10% spares for each type and size of conductor in the conduit, with a minimum of two spares for each type and size. For calculations of spare capacity, round all fractional amounts up to the next whole number. For example, if there are 21 conductors, round the 2.1 spare conductor calculation to 3.

b. Conduit that is routed in part or entirely within NEC classified (hazardous) areas, provide 15% spares for each type and size of conductor in the conduit, with a minimum of two spares for each type and size. For calculations of spare capacity, round all fractional amounts up to the next whole number. For example, if there are 21 conductors, round the 2.1 spare conductor calculation to 3.

14. Cable and Conductor Separation Requirements:

a. Follow the minimum standards of the latest publication of IEEE 518, Paragraph 6.4.
b. The following are minimum standards. If noise coupling, EMI, or RFI become an issue in any installation, then measures shall be taken above and beyond those in IEEE 518 in order to eliminate the coupling or interference.

c. Voltage level and signal types are defined as follows:
   i. Level 1 – Analog signals of less than 50 V and digital signals of less than 16 V.
   ii. Level 2 – Analog signals greater than 50 V and switching circuits.
   iii. Level 3 – Switching signals greater than 50 V, analog signals greater than 50 V, regulating signals of 50 V with currents less than 20 A, and AC feeders less than 20 A.
   iv. Level 4 - AC and DC busses of 0 V to 1000 V with currents between 20 A and 800 A.
   v. Level 4S – AC and DC busses greater than 1000V and/or greater than 800A.

d. Separation Tables:

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15. Wiring Standards:
   a. Jumpering of control, signal, and common or return conductors shall not be allowed unless specifically called out in contract drawings.
   b. All PLC I/O modules have isolated inputs and outputs. Therefore, PLC I/O and field devices shall not have any signals jumpered or shared at the device or I/O module.
   c. All field devices, including but not limited to switches, shall not share a conductor for any signals. For example, a pair of limit switches shall be wired with four conductors and not three.

### Reference Standards

1. NEC Article 300, Wiring Methods.
2. NEC Article 346, Rigid Metal Conduit.
3. NEC Article 347, Rigid Nonmetallic Conduit.
4. NEC Article 351, Liquid-Tight Flexible Metal Conduit.
5. NEC Article 370, Outlet, Switch and Junction Boxes and Fittings.
6. NEC Article 500, Hazardous (Classified) Locations.
8. UL Standard No. 6, Rigid Metal Electrical Conduit.
10. UL Standard No. 50, Electrical Cabinets and Boxes.
11. UL Standard No. 360, Liquid-Tight Flexible Steel Conduit.
12. UL Standard 467, Electrical Grounding and Bonding Equipment.
13. UL Standard No. 514, Electrical Outlet Boxes and Fittings.
14. UL Standard No. 651, Schedule 40 and 80 PVC Conduit.
15. UL Standard No. 886, Electrical Outlet Boxes and Fittings for Use in Hazardous Locations.
16. ANSI C80.1, Specification for Zinc Coated Rigid Steel Conduit.
17. ANSI C80.5, Specification for Rigid Aluminum Conduit.
18. NEMA TC3, PVC Fittings for Use with Rigid PVC Conduit and Tubing.
19. NEMA RN1, PVC Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit.
Section 2 - 600 Volt Conductors

This section provides the detailed requirements for 600-volt conductors. The types of 600-volt conductors and appurtenances detailed include the following:

- Insulated cable for installation in raceways.
- Multi-conductor power cables for installation in Cable Tray systems.

Section 2.A - Detailed Specifications

1. Insulated Cable In Raceways:
   a. Material: Single, stranded, copper conductor cable conforming to ASTM B 3 and B 8 with cross-linked polyethylene, cross-linked polyolefin, ethylene propylene, or thermoplastic insulation, rated 90 degree C in dry locations and 75 degree C in wet locations and listed by UL as Type XHHW.
   b. Wire Sizes: Not smaller than No. 12 AWG for power and lighting and No. 14 AWG for control except No. 16 AWG is permitted in multi-conductor tray cables on power limited circuits.
   c. Stranding: All conductors shall be stranded copper.
   d. Products and Manufacturers:
      i. Wire and Cable Division of Continental Wire and Cable.
      ii. The Okonite Company.
      iii. Pirelli Cable Corporation.
      iv. Anaconda Wire and Cable, a Division of Cablec.
      v. ITT Royal Electric.
      vi. Or approved equal.

2. Power Conductors in Cable Tray:
   a. Material:
      i. Exterior Applications: Multi-conductor type TC tray cable, 90 degree C wet or dry rating. Sunlight resistant with cross-linked polyethylene insulation; impervious, continuous, corrugated aluminum sheath and low temperature PVC jacket. Individual conductors to have type XHHW insulation and are to be color coded for identification.
      ii. Interior Applications: Multi-conductor type TC tray cable, 90 degree C wet or dry rating. Sunlight resistant, low temperature PVC jacket. Individual conductors to have type XHHW insulation and are to be color coded for identification.
   b. Wire Sizes: Not smaller than No. 12 AWG for power and lighting and No. 14 AWG for control.
   c. Stranding: All conductors shall be stranded copper.
   d. Products and Manufacturers:
      i. Southwire.
      ii. The Okonite Company.
      iii. Or approved equal.

3. Cable Connectors, Solderless Type:
   a. For wire sizes up to #6 AWG, use compression type.
b. Products and Manufacturer:
   i. Burndy Hylug.
   ii. T & B Sta-Kon.
   iii. Or approved equal.
c. For sizes #4 AWG and above, use either compression type or bolted type with silver-plated contact faces.
d. For sizes #250 KCM and larger, use connectors with at least 2 cable clamping elements or compression indents and provision for at least 2 bolts for joining to apparatus terminal

4. Wire Identification:
   a. Heat Shrinkable Wire and Cable Labeling System:
      i. White heat-shrinkable irradiated polyolefin shrink-on sleeves. Labels shall be thermal printed. Labels shall be at least 2 inches in width.
      ii. Products and Manufacturers:
         1. B-341 by Brady.
         2. Or approved equal.
   b. Wrap-Around Wire and Cable Labeling System:
      i. Self-laminating white/transparent self-extinguishing vinyl strips. Length shall be sufficient to provide at least two and one half wraps. Labels shall be thermally printed. Labels shall be at least 2 inches in width.
      ii. Products and Manufacturers:
         1. B-427 by Brady.
         2. Or approved equal.

Section 2.B - Installation Details

This section does not contain all installation details for the equipment/system shown, only those that are required by the NEORSD. These details may exceed those required by the equipment manufacturer or local codes.

1. Installation: Unless otherwise specified or shown, install all 600-volt wire and cable in conduit.
2. Bending Radius: To be limited to 6 times cable overall diameter, minimum except where the NEC requires a larger minimum limit.
3. Splices:
   a. Install cable continuous, without splice, from termination to termination.
   b. Where required, splice in junction box using terminal blocks.
   c. Splices in conduits or condulets not permitted.
4. Wire and Terminal Labeling System:
   a. All wire shall be labeled using heat, oil water and solvent resistant, vinyl, self-laminating, self-adhesive wrap type labels as manufactured by the W.H. Brady Co. or approved equal.
   b. Wire and Cable Labels shall be provided as follows:
      i. New, rerouted, or revised wire or cable shall be labeled.
      ii. All insulated conductors shall be labeled.
iii. Bare (uninsulated) conductors shall not be labeled unless otherwise shown or specified.

iv. Wire and cable terminations shall be labeled.

v. Wire labels shall be applied between half an inch and one inch of the completed termination.

vi. Cable labels shall be applied between half an inch and one inch of cable breakout into individual conductors.

vii. Individual conductors in a cable shall be labeled after the breakout as specified for wires.

viii. Wire or cable exiting cabinets, consoles, panels, terminal boxes and enclosures shall be labeled.
     1. Wires or cables shall be labeled within two inches of the entrance to the conduit.

ix. Wire or cable in junction boxes and pull boxes shall be labeled
     1. Wires or cables shall be labeled within two inches of the entrance to the conduit.

x. Wire and cable installed in cable tray shall be labeled.
     1. Wire and cable shall have labels applied at 20 foot maximum intervals.

xi. Wire and cable installed without termination in electrical manholes shall be labeled.
     1. Wire and cable shall have wrap-around labels applied within one foot of exiting the manhole.

xii. Hand written labels are not permitted.

5. Wire and Cable Identification System:
   a. Wire and Cable labels shall be imprinted with an identifying designator.
      i. Wire and cable extending between two devices or items and which does not undergo a change of function shall be identified by a single unique designator as specified below.
   b. All panel wires and field wires shall be color-coded and have an alphanumeric identification tag at each point of termination.
      i. Wire within conduits accessible by removing covers of junction boxes and other devices in the conduit system shall be labeled.
   c. Wiring terminated at a PLC Panel
      i. **Format**
         Source/Destination with Source being the PLC location (or MCC, etc.) and Destination being the field device tag (Instrument, valve, etc.)/wire tag number. The same tag shall be installed on both ends of the wire (the PLC end and the field device end). Wire tag can be either one extra-long self-adhesive, machine-printed wrap around tag or two tags side-by-side. If two tags are used, then the Source goes on the first tag and Destination on the second tag. If the signal source was an MCC or other piece of equipment, then the PLC acronym would be replaced by the MCC or equipment number in the examples below. For analog signals, the cable is also tagged as shown below.
General Format: Source_Destination

For a PLC to Field Device:
PLC_Acronym_Rack#:Slot#:Point#_Device (Instrument Tag)

For an MCC to a Field Device/Wire Number: MCC (Panel ID & bucket)_Device/Wire Number (The Wire Number could be from a schematic, loop diagram, or other drawing).

Examples:
CSF is the acronym for the Easterly Chemical Storage and Feed Facility PLC, E_23_PLC_CSF. Only use the PLC acronym (alpha-numeric abbreviation) that is shown in bold to represent the PLC. (The assumption is that the area number of PLC will match the area number of the field device. If this is not the case, the use the full PLC ID. Example: 23-PLC-CSF).

Analog Input:
CSF_R3:S3:CH0+_E-23-FIT-1010
CSF_R3:S3:CH0-_E-23-FIT-1010
Cable tags (both ends): CSF_E-23-FIT-1010

Analog Output:
CSF_R3:S8:CH1+_E-23-LI-1131
CSF_R3:S8:CH1+_E-23-LI-1131
Cable tags (both ends): CSF_E-23-LI-1131

Discrete Input:

Fused 120 VAC source of power for field contact/Discrete input point: 22011_E-23-ZSC-1011 (Where 22011 is a sample numeric wire tag).

Discrete Output:
CSF_R2:S14:O.1_E-23-PB-1011 (O.1 for OUT1 on the DO module).

Fused 120 VAC source of power for Discrete Output point: 8601_E-23-PB-1011 (Where 8601 is a sample numeric wire tag).

Label spare PLC I/O as follows:
CSF_R3:S3:CH0+_Spare 0+
CSF_R3:S3:CH0-_Spare 0-
Label the wire from the PLC terminal to the interposing field terminal block. Place the label(s) at the end of the wire connected to the interposing field terminal block.

See Figure 1 below for a sample wire tags for discrete outputs that are fused and wired to an interposing relay (Suffixes A and B are added after the discrete output identifier to distinguish between the two wires):

Figure 1 - Wire Tag Example

![Wire Tag Example Diagram]

**SAMPLE WIRE TAGS**
**DISCRETE OUTPUT FUSED AND WIRED TO AN INTERPOSING RELAY**

d. Wiring terminated at a Cabinet, Console, Panel and Enclosure (no PLC)
   i. The wire designator shall consist of an assigned alpha numeric designator.
e. Cables shall be labeled using the equipment/instrument tag number.
f. All terminals and terminal strips and posts shall be numbered with Mylar applique number labels.

6. **Color Code Cables:**
   a. Identification: Identify all conductors by circuit number and phase at each terminal location. Color code conductors as follows:
      i. 120/208 Volt Systems (includes control power):
      ii. 480 Volt Systems: Brown, Orange, Yellow - Phases; Gray- Neutral.
      iii. AC Control Wiring: Red
      iv. DC Control Wiring: Blue (single wire circuits). For (+) DC Control Wiring: Blue; For (-) DC Control Wiring: White with blue trace.
      v. Conductors that remain energized when main disconnecting means
is off: Yellow

vi. Grounding Conductors: Green.

b. Cable color to be continuously applied by manufacturer.

Reference Standards

1. ASTM B 3, Soft or Annealed Copper Wire.
2. ASTM B 8, Concentric-Lay-Stranded Copper Conductors, Hard, Medium-hard or Soft.
3. ICEA S-73-532/NEMA WC57, Control, Thermocouple Extension, and Instrumentation Cables
4. ICEA T-33-655 Low-Smoke, Halogen-Free (LSHF) Polymeric Cable Jackets.
7. UL 44 Thermoset-Insulated Wires and Cables.
8. UL 83, Thermoplastic-Insulated Wires and Cables.
9. UL 83A, Fluoropolymer Insulated Wire.
10. UL 1277, Electrical Power and Control Tray Cables with Optional Optical-Fiber Members
11. UL 1581, Electrical Wires, Cables, and Flexible Cords.
12. UL 1685, Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables.
Section 3 – Instrumentation and Network Cabling

This section provides the detailed requirements for instrumentation cabling. The types of instrumentation cabling include the following:

- Single Shielded Pairs and Triads for Analog Signals
- Multipair Shielded for Analog Signals
- Data Cable for RS-422 Communication
- Computer Communication Cable for Ethernet Protocol
- PLC Data Highway & Remote I/O Communication Cable
- DeviceNet Cable

Section 3.A - Detailed Specifications

1. Single Shielded Pair and Triad Instrument Cable:
   a. Tinned copper, stranded conductors, No. 18 AWG minimum, color coded polyethylene insulation on twisted conductors with 100% coverage aluminum-polyester shield, stranded and tinned No. 18 AWG minimum copper drain wire and overall PVC jacket. Rated for 300 volts minimum.
   b. Color code of pairs shall be black and clear. Color code of triads shall be black, red, and clear.
   c. Pair manufacturer and type:
      i. Belden No. 8719.
      ii. Or approved equal.
   d. Triad manufacturer and type:
      i. Belden No. 8618
      ii. Or approved equal.

2. Multipair Shielded:
   a. Tinned copper, 18 AWG, 7 strand XLPE insulated conductors, twisted in pairs with aluminum-Mylar shield over each pair, silicone rubber fiberglass fire barrier tape, tinned copper drain wire, aluminum Mylar overall shield, Hypalon outer jacket. Rated for 300 volts minimum.
   b. Products and Manufacturers:
      i. Dekoron Poly-set.
      ii. Okonite type SP-OS.
      iii. Belden
      iv. Or approved equal.

3. Data Cable for RS-422 Communication:
   a. Precision-twisted shielded wire of EIA RS-232 and RS-422 standards type, having a uniform number of twists per unit of length. High characteristic impedance, not less than 150 ohms.
   b. Capacitance between wires less than 20pF/foot (60pF/meter).
   c. Solid foil with an overlapped folded seam and drain wire. Coverage shall be not less than 95%.
   d. Outer jacket: Polypropylene.
   e. Product and Manufacturers:
i. Belden 9182.
ii. Or approved equal.

4. **Computer Communication Cable for Ethernet Protocol:**
a. **Application:** Enhanced Category 6 for non-plenum installation (most applications).
   i. Conductor material: solid bare copper
   ii. Conductor size and type: 23 AWG unshielded twisted pairs
   iii. Number of conductor pairs: 4 (with rip cord)
   iv. Conductor insulation: Polyolefin
   v. Jacket material: PVC
   vi. Impedance: 100 Ohms
   vii. Maximum capacitance, unbalanced: 49.2 pf/100m
   viii. UL approved
   ix. Product and Manufacturers:
       1. Belden 1874A for plenum applications.
       2. Or approved equal.

b. **Application:** Enhanced Category 6 for plenum installation.
   i. Conductor material: solid bare copper
   ii. Conductor size and type: 23 AWG unshielded twisted pairs
   iii. Number of conductor pairs: 4 (with rip cord)
   iv. Conductor insulation: FEP Teflon
   v. Jacket material: Flamarrest
   vi. Impedance: 100 Ohms
   vii. Maximum capacitance, unbalanced: 49.2 pf/100m
   viii. UL approved, plenum rated
   ix. Product and Manufacturers:
       1. Belden 1874A for plenum applications.
       2. Or approved equal.

c. **Conductor insulation color codes:**
   i. Pair No. 1: white/blue stripe & blue
   ii. Pair No. 2: white/orange stripe & orange
   iii. Pair No. 3: white/green stripe & green
   iv. Pair No. 4: white/brown stripe & brown

5. **PLC Remote I/O Communication Cable:**
a. **Application:** Communication between PLCs and Remote I/O.
   i. Conductor: Twin axial stranded, tinned copper 20 AWG.
   ii. Conductor insulation: Polyethylene
   iii. Shield: 100% coverage foil & minimum 55% coverage tinned copper braid with drain wire
   iv. Impedance: 78 Ohms.
   v. Nominal capacitance: 19.7 pf/ft.
   vi. Nominal attenuation: 7.5 dB/100 ft. @ 100.0 MHz.
   vii. Outer Jacket: Blue PVC.
   viii. Product and Manufacturers:
       1. Belden 9463.
       2. Or approved equal.

b. **Conductor insulation color codes:** clear and blue
Section 3.B - Installation Details

This section does not contain all installation details for the equipment/system shown, only those that are required by the NEORSD. These details may exceed those required by the equipment manufacturer or local codes.

1. Ground shield at panel end only. Opposite end is to be isolated.
2. Shield wires are to be terminated in panels, on their appropriate terminal, with their corresponding circuits.
3. Terminate stranded conductors with pre-insulated crimp type spade, insulated pin type or ring tongue terminal properly sized to fit fastening device and to fit wire size.
4. Instrumentation, communications, or network cable to be continuous. Splicing of these cables is not permitted.

Reference Standards

1. NFPA 70, National Electrical Code.
3. Underwriters Laboratories, Inc. (UL)
Section 4 – Patch Panels

Created: May 2012       Last Edited: 1/7/2013

This section provides the detailed requirements for patch panels.

Section 4.A - Detailed Specifications

1. All fiber optic patch panels shall be wall mounted NEMA 4X enclosures. Fiber optic patch panels shall be EIA standard 19-inch width rack mounted enclosures.
2. Provide fiber optic cable patch panels which meet the following requirements:
   a. Furnish panels with the following accessories:
      i. Splice trays
      ii. Cable strain relief
      iii. Bend radius protectors
      iv. Routing guides
      v. Grommeted cable entries
      vi. SD simplex adapters and adapter plates
      vii. Sufficient working space for removal of connectors
      viii. Identification label
      ix. Cable management hardware.
   b. Furnish each cabinet with a key lock and two (2) keys. All cabinets provided are to be keyed alike so that a single key opens all cabinets.
   c. Type: 316 stainless steel, 14-gauge enclosure, rated NEMA 4X. Solid centerpost with heavy stiffener. Stainless steel captivated door screws, oil resistant gasket with two 12 gauge steel panels mounted on collar studs.
      i. Minimum size shall be 24” width, 24” high, and 12” deep.

Section 4.B - Installation Details

This section does not contain all installation details for the equipment/system shown, only those that are required by the NEORSD. These details may exceed those required by the equipment manufacturer or local codes.

Reference Standards

NA
Section 5 – Network Cabinets

Created: May 2012       Last Edited: 8/8/2017

Refer to Specification Section 40 66 00 – 2.07 for the detailed requirements for network cabinets.

Section 5.A - Detailed Specifications

1. The cabinets shall have the following features:
   a. Provide all electrical components and devices, support hardware, fasteners, interconnecting wiring required to make the cabinets complete and operational units.
   b. Locate and install all devices and components so that connections can be easily made and so that there is ample room for servicing each item.
   c. Adequately support components mounted within the cabinet to prevent any movement.
   d. Cabinets shall be NEMA 12 rated for control room locations.
   e. Provide wall-mounting supports.
   f. Provide all holes and cutouts for installation of conduit and equipment.
   g. Provide automatically controlled closed loop ventilation fans to maintain temperature.
   h. Refer to Volume 5 of PCS Automation Standards and Conventions Manual for specific cabinet security requirements.

Section 5.B - Installation Details

This section does not contain all installation details for the equipment/ system shown, only those that are required by the NEORSD. These details may exceed those required by the equipment manufacturer or local codes.

Reference Standards

Specification Section 40 66 00 – 2.07.
Section 6 – Modular Motor Protection System

Created: May 2012       Last Edited: 9/29/2017

This section provides the detailed requirements for a modular motor protection system (MPS).  Rockwell model 825-P is obsolete.  Update with Rockwell E300 electronic overload relay with Ethernet communications.

Section 6.A - Detailed Specifications

1. General:
   a. The motor protection system (MPS) shall have a current operating range of 0.5 to 5000 amps.
   b. The MPS shall provide current, voltage, and temperature-based protection functions.
      i. Current measurement shall be performed by a separate three-phase converter module that provides electrical isolation between the primary measurement circuit and the MPS.
      ii. The MPS shall continue to function in the event of saturation of primary current transformers.
      iii. Three-phase converter modules shall be capable of direct connection and mounting to contactors in low voltage applications.
      iv. In medium and high voltage applications the converter module shall be wired in series with secondary windings from primary current transformers with a secondary current rating of 1 or 5 amps.
      v. The MPS shall provide terminations and monitoring functions for motor winding embedded positive temperature coefficient (PTC) thermistors.
   c. A dedicated trip relay with Form C contacts shall be provided for use in a motor starter control circuit.
   d. A minimum of two auxiliary relay outputs with minimum Form A contacts shall be provided that are assignable in function.
   e. All relays shall be programmable for failsafe or non-failsafe operation.
   f. The MPS shall provide a minimum of two digital inputs that are configurable for function.
   g. Terminal connections and monitoring circuitry for connection of a core balance current transformer for ground fault detection shall be included in the standard design of the MPS.
   h. A fiber optic port shall be provided for connection to an RTYD temperature monitoring scanner module.
   i. The MPS shall operate from 85 to 264V AC, 60 Hz or 85 to 275V DC.
   j. The front panel operator interface shall consist of a minimum two-line, sixteen character backlit LCD with up, down, left, and right navigation keys.
k. A Test/Reset button shall be provided on the front panel of the MPS.
l. LED indicators shall be provided to indicate that the MPS is enabled and to indicate a trip or warning event.
m. The cause of trip and warning events shall be identified on the LCD.
n. The MPS shall be equipped with an RS-232 serial communications port on the front panel with a DB9 connector. The port shall allow MPS monitoring, programming, and flash memory upgrades.
o. There shall be three levels of access to MPS information and settings. Two of the three levels will require a password to gain access.
p. The following cards shall be included:
   i. Three-phase voltage input card with the following features:
      2. 300V AC rating
      3. Wye, delta, and open delta potential transformer inputs
   ii. I/O expansion card with the following features:
       1. Expansion card I/O is in addition to previously specified I/O
       2. Three configurable inputs
       3. Four relay outputs with minimum Form A contacts
       4. One configurable 4 to 20mA isolated analog output
p. DeviceNet communications card
r. In addition to the thermistor input capability previously specified, the MPS shall be provided with an RTD scanner module with the following features:
   i. Twelve RTD input channels
   ii. Shall be compatible with commonly used RTD types including:
       1. 100 ohm platinum
       2. 100 ohm nickel
       3. 120 ohm nickel
       4. 10 ohm copper
   iii. Capability to be mounted separate from the MPS and near the motor to minimize wiring.
   iv. Fiber optic port for communication to MPS.
   v. Powered by 120/240V AC, 60 Hz
s. The MPS shall be provided with all required interconnecting cables and wiring.

2. Construction:
a. MPS shall be modular in construction allowing for re-configuration and expansion through the use of field-installable and pluggable cards or modules
b. The MPS shall be rated NEMA 12 (IP65) when installed in an appropriate enclosure.
c. Wiring terminals shall provide IP20 finger protection
d. Wiring terminal connectors shall be pluggable.
e. Terminal markings shall comply with CENELEC and EN 50012.
f. MPS and accessories shall be capable of operation without disruption in a -4°F to +140°F temperature range and 0 to 95% humidity range, non-
condensing.
g. The MPS shall be able to withstand a shock of 30G (per IEC 68-2-27)
h. The MPS shall be able to operate without disruption with vibration levels up to 3G (per IEC 68-2-6).

3. Protection Functions:
   a. Current Elements:
      i. Thermal overload
      ii. Current imbalance / phase loss
      iii. Ground fault – residual method
      iv. Ground fault – zero sequence method
      v. Undercurrent – load loss
      vi. Overcurrent – load jam
      vii. Short circuit
      viii. Phase reversal – current based
      ix. Under and over-frequency – current based
   b. Voltage Elements:
      i. Undervoltage, Overvoltage
      ii. Phase reversal – voltage based
      iii. Under and over-frequency – voltage based
   c. Power Elements:
      i. Underpower
      ii. Power factor
      iii. Reactive power
   d. Temperature Elements:
      i. PTC thermistor
      ii. Stator, bearing, ambient, and other RTD
   e. Motor Starting Elements:
      i. Start inhibit – starts/hour
      ii. Emergency start
      iii. Acceleration time monitoring
      iv. Speed switch monitoring
      v. Anti-backspin timer
      vi. Reduced voltage starting
      vii. Two speed or reversing motor control
   f. Other Elements:
      i. Remote trip (e.g. from a vibration switch)

4. Metering Functions:
   a. The MPS shall be able to display the following parameters. Unless otherwise identified, accuracy shall be ± 2%.
      i. Individual phase current in amps
      ii. Average current in amps
      iii. Average motor load as a percentage of full motor current rating
      iv. Percent current imbalance or asymmetry
      v. Percent voltage imbalance or asymmetry
      vi. Residual ground fault in amps
vii. Zero sequence (core balance) ground fault current in amps
viii. Phase-to-phase voltage
ix. Phase-to-neutral voltage
x. Three-phase average phase-to-phase voltage
xi. Three-phase average phase-to-neutral voltage
xii. Real three-phase power in kW (± 5% accuracy)
xiii. Reactive three-phase power in kVAR (± 5% accuracy)
xiv. Apparent three-phase power in kVA (± 5% accuracy)
xv. Power factor
xvi. Frequency (± 0.1 Hz of reading)
xvii. Individual RTD temperature measurements in ºF or ºC (± 2 ºC accuracy).
xviii. The default display mode shall automatically scroll through the instantaneous current and voltage measurements. In addition, the user may add the following values:
   1. ground current
   2. current imbalance
   3. frequency
   4. percent thermal capacity used
   5. voltage imbalance
   6. power
   7. RTD temperature.

5. Control Functions:
   a. The MPS shall have provisions to reset a trip through contact closure to an assigned input.
   b. The MPS shall incorporate control capability for star (wye)-delta motor applications. The MPS shall switch the contactor arrangement on the basis of the motor operating current falling below 110% of motor rated current on acceleration to full speed. A setting shall be provided that allows for programming of a maximum star contactor configuration time.
   c. The MPS shall provide two on-delay and two off-delay timers for control purposes. The timers shall be adjustable from 0 to 240 seconds.
   d. The MPS shall allow for disabling of user-selected protection functions by contact closure to a digital input.
   e. The isolated analog output shall be selectable for output of one of the following signals: maximum phase current, average current, percent load, percent thermal capacity utilized, maximum winding temperature, maximum bearing temperature, kW power, or power factor.
   f. Load control settings shall allow control of the MPS auxiliary relays on the basis of motor operating current, percent thermal capacity used, or kW power.

6. Communications:
   a. Network communications shall be accomplished through a single communications card installed in an expansion slot of the MPS. Communications shall be DeviceNet.
b. The DeviceNet communications card must support DeviceLogix component technology.

7. Statistical Data:
   a. The MPS shall provide the following statistical values related to motor operation.
      i. Percent thermal capacity utilized (%TCU)
      ii. Time to trip
      iii. Time to start
      iv. Elapsed time of operation
      v. Running time
      vi. Stopped time
      vii. Percent time running
      viii. Number of start cycles
      ix. Number of emergency start operations
      x. Number of starts available
      xi. Time and date of last reset

8. Diagnostic Historical Data:
   a. The MPS shall store diagnostic data related to the 14 most recent trip events. The data provided shall include:
      i. Time and date of event
      ii. Trip identification
      iii. Phase current magnitude and angle values at time of trip
      iv. Ground fault current magnitude and angle values at time of trip
      v. Phase voltage magnitude and angle values at time of trip

9. Standards:
   a. The MPS shall be designed for compliance to the following standards:
      i. EN 60947-4-1
      ii. EN 60947-5-1
      iii. UL 508
      iv. UL 1053
      v. CSA C22.2 No. 14

10. Manufacturer and Model:
    a. Approved manufacturer and series for the modular motor protection system (MPS):
       i. Provide Allen-Bradley 825-P series Modular Motor Protection System with the following components and options:
          1. Base Unit – Catalog No. 825-PD
          2. Converter Module - 825-MCM series
          3. Bus Bar for Converter Module, as required
          4. Core Balance Transformer – 825-CBCT
          5. RTD Scanner Module – Catalog No. 825-PR12D
          6. Voltage Input Card - Catalog No. 825-PVS
          7. Expansion I/O Card – 825 PIO series
          8. DeviceNet Communication Card - Catalog No. 825-PDN
Section 6.B - Installation Details

CONTRACTOR to provide and install all options, cables, and wiring that was not factory installed. CONTRACTOR to install MPS with all options and provide and install all mounting hardware and supports.