c. Make and type.
d. Model number and unit size.
e. Manufacturer's serial number.
f. Sheave make, size in inches, and bore.
g. Number, make, and size of belts.

2. Motor Data:

a. Motor make, and frame type and size.
b. Horsepower and rpm.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches, and bore.

3. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm.
b. Total system static pressure in inches wg.
c. Fan rpm.
d. Discharge static pressure in inches wg.
e. Filter static-pressure differential in inches wg.
f. Coil static-pressure differential in inches wg for all coils.
g. Outdoor airflow in cfm.
h. Return airflow in cfm.
i. Outdoor-air damper position.
j. Return-air damper position.

D. Apparatus-Coil Test Reports:

1. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.
b. Average face velocity in fpm.
c. Air pressure drop in inches wg.
d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
e. Return-air, wet- and dry-bulb temperatures in deg F.
f. Entering-air, wet- and dry-bulb temperatures in deg F.
g. Leaving-air, wet- and dry-bulb temperatures in deg F.
h. Water flow rate in gpm.
i. Water pressure differential in feet of head or psig.
j. Entering-water temperature in deg F.
k. Leaving-water temperature in deg F.

E. Fan Test Reports: For supply, return, and exhaust fans, include the following:

1. Fan Data:

a. System identification.
b. Location.
c. Make and type.
d. Model number and size.
e. Manufacturer's serial number.
f. Sheave make, size in inches, and bore.

2. Motor Data:

    a. Motor make, and frame type and size.
    b. Horsepower and rpm.
    c. Volts, phase, and hertz.
    d. Full-load amperage and service factor.
    e. Sheave make, size in inches, and bore.
    f. Number, make, and size of belts.

3. Test Data (Indicated and Actual Values):

    a. Total airflow rate in cfm.
    b. Total system static pressure in inches wg.
    c. Fan rpm.
    d. Discharge static pressure in inches wg.
    e. Suction static pressure in inches wg.

F. Round, Flat-Oval, and Rectangular Duct Traverse Reports:

1. Report Data:

    a. System and air-handling-unit number.
    b. Location and zone.
    c. Duct static pressure in inches wg.
    d. Duct size in inches.
    e. Duct area in sq. ft..
    f. Indicated airflow rate in cfm.
    g. Indicated velocity in fpm.
    h. Actual airflow rate in cfm.
    i. Actual average velocity in fpm.

G. Air-Terminal-Device Reports:

1. Unit Data:

    a. System and air-handling unit identification.
    b. Location and zone.
    c. Apparatus used for test.
    d. Area served.
    e. Number from system diagram.
    f. Size.
    g. Effective area in sq. ft..

2. Test Data (Indicated and Actual Values):

    a. Airflow rate in cfm.
    b. Air velocity in fpm.
    c. Preliminary airflow rate as needed in cfm.
    d. Preliminary velocity as needed in fpm.
    e. Final airflow rate in cfm.
    f. Final velocity in fpm.

H. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:

1. Unit Data:

a. System and air-handling-unit identification.
b. Location and zone.
c. Room served.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.
b. Entering-water temperature in deg F.
c. Leaving-water temperature in deg F.
d. Water pressure drop in feet of head or psig.
e. Entering-air temperature in deg F.
f. Leaving-air temperature in deg F.

I. Instrument Calibration Reports:

1. Report Data:

a. Instrument type and make.
b. Serial number.
c. Application.
d. Dates of use.
e. Dates of calibration.

3.10 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION 230593

SECTION 230713 - DUCT INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulating the following duct services:

1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed supply and outdoor air.
3. Indoor, concealed return located in unconditioned space.

B. Related Sections:

1. Section 230719 "HVAC Piping Insulation."
2. Section 233113 "Metal Ducts" for duct liners.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

1.3 QUALITY ASSURANCE

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with the scheduled requirements in PART 3 of this specification for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C553, Type II and ASTM C1290, Type III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Subject to compliance, provide products by one of the following:

a. Johns Manville
b. Knauf Insulation
c. Owens Corning

2.2 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

C. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

2.3 MASTICS AND COATINGS

A. Materials shall be compatible with insulation materials, jackets, and substrates.

B. Vapor-Retarder Mastic: Water based; suitable for indoor use on below ambient services.

1. Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.
2. Service Temperature Range: Minus 20 to plus 180 deg F.
3. Comply with MIL-PRF-19565C, Type II, for permeance requirements.
4. Color: White.

C. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.

1. Water-Vapor Permeance: ASTM E96, greater than 1.0 perm at manufacturer's recommended dry film thickness.
2. Service Temperature Range: Minus 20 to plus 180 deg F.
3. Color: White.

2.4 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: Aluminum.

2.5 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.

2.6 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for ducts.

2.7 TAPES

A. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.

1. Width: 3 inches.
2. Thickness: 6.5 mils.
3. Adhesion: 90 ounces force/inch in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch in width.
6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

2.8 SECUREMENTS

A. Aluminum Bands: ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal or closed seal.

B. Insulation Pins and Hangers:

1. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

a. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
b. Spindle: Fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

2. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

a. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.

b. Spindle: Fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
c. Adhesive-backed base with a peel-off protective cover.

3. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

a. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch-wide, stainless steel or Monel.

D. Wire: 0.062-inch soft-annealed, stainless steel.

2.9 CORNER ANGLES

A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC according to ASTM D1784, Class 16354-C. White or color-coded to match adjacent surface.

B. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.

PART 3 - EXECUTION

3.1 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.

B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Keep insulation materials dry during application and finishing.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install insulation with least number of joints practical.

I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

K. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.

    a. For below ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.

L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.3 PENETRATIONS

A. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

B. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.

1. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

C. Insulation Installation at Floor Penetrations:

1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.4 INSTALLATION OF MINERAL-FIBER INSULATION

A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

    a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
    b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
    c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
    d. Do not overcompress insulation during installation.
    e. Impale insulation over pins and attach speed washers.
    f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

    a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
    b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.

5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.
6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.5 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:

1. Indoor, concealed supply air.
2. Indoor, exposed supply air.
3. Indoor, concealed return located in unconditioned space.
4. Indoor, exposed return located in unconditioned space.

B. Items Not Insulated:

1. Fibrous-glass ducts.
2. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
3. Factory-insulated flexible ducts.
4. Factory-insulated plenums and casings.
5. Flexible connectors.
6. Vibration-control devices.
7. Factory-insulated access panels and doors.

3.6 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Concealed, Supply-Air Duct and Plenum Insulation: Mineral-fiber blanket, 2 inches thick and 1.0-lb/cu. ft. nominal density. Minimum installed value shall be R-6 per IECC-2018 requirements.

B. Indoor, Return-Air Duct and Plenum in Unconditioned Space Insulation: Mineral-fiber blanket, 2 inches thick and 1.0-lb/cu. ft. nominal density. Minimum installed value shall be R-6 per IECC-2018 requirements.

C. Exposed within Equipment Rooms, Supply-Air Duct and Plenum Insulation: Mineral-fiber blanket, 2 inches thick and 1.0-lb/cu. ft. nominal density. Minimum installed value shall be R-6 per IECC-2018 requirements.

END OF SECTION 230713

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 230719 - HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulation for HVAC piping systems.

B. Related Sections:

1. Section 230713 "Duct Insulation" for duct insulation.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 QUALITY ASSURANCE

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

1.4 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.5 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come into contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested in accordance with ASTM C871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable in accordance with ASTM C795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C534/C534M, Type I for tubular materials, Type II for sheet materials.

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

a. Aeroflex USA, Inc.
b. Armacell LLC (Basis of Design)
c. K-Flex USA

2. Maximum conductivity for scheduled thickness

a. Chilled water: 0.27 BTU-in/hr.-sq. ft.-Deg. F at a mean rating temperature of 75 Deg. F.

G. Mineral-Fiber, Preformed Pipe: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C547.

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

a. Johns Manville
b. Knauf Insulation
c. Owens Corning

2. Preformed Pipe Insulation: Type I, Grade A with factory-applied ASJ-SSL.
3. 850 deg F.
4. Maximum conductivity for scheduled thicknesses

a. Chilled water: 0.27 BTU-in/hr.-sq. ft.-Deg. F at a mean rating temperature of 75 Deg. F.
b. Heating water: 0.29 BTU-in/hr.-sq. ft.-Deg. F at a mean rating temperature of 125 Deg. F.

5. Factory fabricate shapes in accordance with ASTM C450 and ASTM C585.
6. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2.2 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Flexible Elastomeric and Polyolefin Adhesive: Solvent-based adhesive.

1. Flame-spread index shall be 25 or less and smoke-developed index shall be 50 or less as tested in accordance with ASTM E84.
2. Wet Flash Point: Below 0 deg F.
3. Service Temperature Range: 40 to 200 deg F.
4. Color: Black.

C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

D. ASJ Adhesive and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A, for bonding insulation jacket lap seams and joints.

E. PVC Jacket Adhesive: Compatible with PVC jacket.

2.3 MASTICS AND COATINGS

A. Materials shall be compatible with insulation materials, jackets, and substrates.

B. Vapor-Retarder Mastic, Water Based: Suitable for indoor use on below-ambient services.

1. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
2. Service Temperature Range: 0 to plus 180 deg F.
3. Comply with MIL-PRF-19565C, Type II, for permeance requirements.
4. Color: White.

C. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.

1. Water-Vapor Permeance: ASTM E96/E96M, greater than 1.0 perm at manufacturer's recommended dry film thickness.
2. Service Temperature Range: 0 to plus 180 deg F.
3. Color: White.

2.4 SEALANTS

A. Materials shall be as recommended by the insulation manufacturer and shall be compatible with insulation materials, jackets, and substrates.

B. Joint Sealants:

1. Permanently flexible, elastomeric sealant.

a. Service Temperature Range: Minus 150 to plus 250 deg F.
b. Color: White or gray.

C. ASJ Flashing Sealants:

1. Fire- and water-resistant, flexible, elastomeric sealant.

2. Service Temperature Range: Minus 40 to plus 250 deg F.
3. Color: White.

2.5 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.

2.6 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Fabric: Approximately 2 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in. for covering pipe and pipe fittings.

B. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for pipe.

2.7 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C1136, Type I, unless otherwise indicated.

B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Adhesive: As recommended by jacket material manufacturer.
2. Color: White.
3. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.

a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

2.8 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.

1. Width: 3 inches.
2. Thickness: 11.5 mils.
3. Adhesion: 90 ounces force/inch in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch in width.
6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

2.9 SECUREMENTS

A. Bands:

1. Stainless Steel: ASTM A240/A240M, Type 304 or Type 316; 0.015 inch thick, 1/2 inch wide with wing seal or closed seal.

B. Staples: Outward-clinching insulation staples, nominal 3/4 inch wide, stainless steel or Monel.

C. Wire: 0.062-inch soft-annealed, stainless steel.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Coordinate insulation installation with the tradesman installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless steel surfaces, use demineralized water.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping, including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and of thicknesses required for each item of pipe system, as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during storage, application, and finishing. Replace insulation materials that get wet.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends attached to structure with vapor-barrier mastic.
3. Install insert materials and insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward-clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward-clinching staples along edge at 2 inches o.c.

    a. For below-ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, in accordance with insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than 25 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches in similar fashion to butt joints.

P. For above-ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.

3.3 PENETRATIONS

A. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

B. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

1. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

C. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.4 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials, except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, Mechanical Couplings, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, mechanical couplings, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation made from same material and density as that of adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation of same material and thickness as that used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation of same material, density, and thickness as that used for adjacent pipe. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation of same material, density, and thickness as that used for adjacent pipe. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers, so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
6. Insulate flanges, mechanical couplings, and unions using a section of oversized preformed pipe insulation to fit. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Stencil or label the outside insulation jacket of each union with the word "union" matching size and color of pipe labels.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.

8. For services not specified to receive a field-applied jacket, except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing, using PVC tape.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as that of adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union at least 2 times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.5 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as that of pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as that of pipe insulation when available.
2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties, and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.6 INSTALLATION OF MINERAL-FIBER INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands, and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward-clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive, as recommended by insulation material manufacturer, and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as that of straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as that of straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

3.7 FIELD-APPLIED JACKET INSTALLATION

A. Where PVC jackets are indicated and for horizontal applications, install with 1-inch overlap at longitudinal seams and end joints. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

3.8 PIPING INSULATION SCHEDULE, GENERAL

A. Insulation conductivity and thickness per pipe size shall comply with schedules in this Section or with requirements of authorities having jurisdiction, whichever is more stringent.

B. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

3.9 INDOOR PIPING INSULATION SCHEDULE

A. Chilled Water, Above 40 Deg F:

1. NPS 1 and Smaller: Insulation shall be one of the following:

a. Flexible Elastomeric: 3/4 inch thick.
b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 3/4 inch thick.

2. NPS 1 through 1-3/4: Insulation shall be one of the following:

a. Flexible Elastomeric: 1-1/2 inch thick.
b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1-1/2inch thick.

3. NPS 4 and larger: Insulation shall be the following:

a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 2inch thick.

B. Heating-Hot-Water Supply and Return, 200 Deg F and Below:

1. NPS 1-1/4 and Smaller: Insulation shall be the following:

a. Mineral-Fiber, Preformed Pipe, Type I: 1-1/2 inch thick.

2. NPS 1-1/2 and Larger: Insulation shall be the following:

a. Mineral-Fiber, Preformed Pipe, Type I: 2 inch thick.

C. Cooling Coil Condensate:

1. All sizes: Insulation shall be the following:

a. Flexible Elastomeric: 1/2 inch thick.

3.10 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Pipe Fittings, All Areas: PVC: 20 mils thick.

END OF SECTION 230719

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 230800 - COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes commissioning process requirements for the following HVAC&R systems, assemblies, and equipment:

1. Distribution systems, including air distribution (heating and cooling) systems, exhaust systems, and air-handling units.
2. Terminal and packaged units, including fan-coil units.
3. Controls and instrumentation, including BAS.
4. Systems testing and balancing verification, including heating-water piping systems, chilled-water piping systems, supply-air systems, return-air systems, and exhaust-air systems.

B. Related Requirements:

1. Section 019113 "General Commissioning Requirements" for general commissioning process requirements and Commissioning Coordinator responsibilities.

1.2 DEFINITIONS

A. BAS: Building automation system.

B. DDC: Direct digital controls.

C. HVAC&R: Heating, Ventilating, Air Conditioning, and Refrigeration.

D. "Systems," "Subsystems," "Equipment," and "Components": Where these terms are used together or separately, they shall mean "as-built" systems, subsystems, equipment, and components.

E. TAB: Testing, adjusting, and balancing.

1.3 INFORMATIONAL SUBMITTALS

A. Commissioning Plan:

1. A narrative description of the activities that will be accomplished during each phase of commissioning, including the personnel intended to accomplish each of the activities.
2. A listing of the specific equipment, appliances or systems to be tested and a description of the tests to be performed.
3. Functions to be tested including, but not limited to, calibrations and economizer controls.
4. Conditions under which the test will be performed. Testing shall affirm winter and summer design conditions and full outside air conditions.
5. Measurable criteria for performance.

B. Preliminary Commissioning Report

1. Completed IECC-2018 Commissioning Compliance Checklist
2. Itemization of deficiencies found during testing required by this section that have not been corrected at the time of report preparation.
3. Identification of deferred tests that cannot be performed at the time of report preparation because of climatic conditions.
4. Climatic conditions required for performance of the deferred tests.
5. Results of functional performance tests.
6. Functional performance test procedures used during the commissioning process, including measurable criteria for test acceptance.

C. Final Commissioning Report

1. Results of functional performance tests.
2. Disposition of deficiencies found during testing, including details of corrective measures used or proposed.
3. Functional performance test procedures used during the commissioning process including measurable criteria for test acceptance, provided herein for repeatability.
4. Identification of deferred tests that could not be performed due to climatic conditions
5. Climatic conditions required for performance of the deferred tests.
6. Final versions of any additional data provided in the Preliminary Commissioning Report.

1.4 QUALITY ASSURANCE

A. Commissioning shall be provided by an Approved Agency as defined in IECC-2018 and approved by the code official.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 GENERAL TESTING REQUIREMENTS

A. Certify that HVAC&R systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents and approved Shop Drawings and submittals.

B. Certify that HVAC&R instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents and approved Shop Drawings and submittals, and that pretest set points have been recorded.

C. Certify that TAB procedures have been completed and that TAB reports have been submitted, discrepancies corrected, and corrective work approved.

D. Set systems, subsystems, and equipment into operating mode to be tested according to approved test procedures (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

E. Perform tests using design conditions, whenever possible.

1. Simulated conditions may, with approval of Architect, be imposed using an artificial load when it is impractical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by Commissioning Coordinator and document simulated conditions and methods of simulation. After tests, return configurations and settings to normal operating conditions.
2. Commissioning test procedures may direct that set points be altered when simulating conditions is impractical.
3. Commissioning test procedures may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are impractical.

F. If tests cannot be completed because of a deficiency outside the scope of the HVAC&R system, document the deficiency and report it to Owner. After deficiencies are resolved, reschedule tests.

G. If seasonal testing is deemed necessary due to climatic conditions, complete appropriate initial performance tests and documentation and schedule seasonal tests.

H. Coordinate schedule with, and perform the following activities at the direction of, Commissioning Coordinator.

I. Comply with construction checklist requirements, including material verification, installation checks, start-up, and performance tests requirements specified in Sections specifying HVAC systems and equipment.

J. Provide technicians, instrumentation, tools, and equipment to complete and document the following:

1. Performance tests.
2. Demonstration of a sample of performance tests.
3. Commissioning tests.
4. Commissioning test demonstrations.

3.2 TAB COMMISSIONING TESTS

A. TAB Verification: Commissioning Agent shall review the TAB report for completeness and deficiencies and prepare a written review report. Subsequent TAB report reviews shall be performed until all comments have been addressed.

3.3 BAS VERIFICATION

A. Sensor Calibration: Commissioning Agent shall verify that all HVAC control system components are calibrated and adjusted to operate in accordance with the approved plans.

B. Sequences of Operation

1. Prerequisites: completion of control sensor installation and programming logic on the system to be verified and other systems that could affect performance testing.

2. Condition of the Test: Commissioning agent shall simulate design conditions in order to verify the sequence of operations of HVAC equipment matches that indicated on the design documents. Sampling rates shall be as described below.

    a. Air Handling Unit: 100 percent of each model/size unit.
    b. Terminal Units: 10 percent of each model/size unit.
    c. Fan Coil Units: 10 percent of each model/size unit.
    d. Equipment Not Explicitly Listed: 100 percent of each model/size unit.

3. Acceptance Criteria: All sequence of operation logic shall match that shown on the design documents unless written approval from the Owner and Engineer is obtained.

3.4 TERMINAL UNIT EQUIPMENT COMMISSIONING TESTS

A. Variable-Air-Volume Terminal Air Units with Coils:

1. Prerequisites: Installation verification of the following where included in infrastructure:

    a. Occupancy Input Device: Occupancy sensor.
    b. Occupancy Output Device: DDC system binary output.
    c. Room Temperature Input Device: Room thermostat.
    d. Room Temperature Output Device: Electronic damper actuators and control-valve operators.
    e. Display the following in the BAS user interface:

        1) Room/area served.
        2) Room occupied/unoccupied.
        3) Room temperature indication.
        4) Room temperature set point.
        5) Room temperature set point, occupied.
        6) Room temperature set point, unoccupied.
        7) Air-damper position command as percentage open.
        8) Control-valve position command as percentage open.

2. Conditions of the Test:

    a. Commissioning Test Demonstration Sampling Rate: 10 percent of each model/size unit.
    b. Temperature Control - Occupied: Start with the room unoccupied. Occupy the room and observe the change to occupied status. Observe temperature control until room temperature is stable at occupied set point plus or minus 1.0 deg F.
    c. Temperature Control - Unoccupied: Start with the room occupied. Vacate the room and observe the change to unoccupied status. Observe temperature control until room temperature is stable at unoccupied set point plus or minus 1.0 deg F.

3. Acceptance Criteria:

    a. Temperature Control - Occupied:

        1) Control system status changes from "occupied" to "unoccupied" after the specified time.
        2) Room temperature is stable at occupied set point plus or minus 1.0 deg F within 10 minutes of occupancy. Room temperature does not overshoot or undershoot set point by more than 2.0 deg F during transition.

b. Temperature Control - Unoccupied:

1) Control system status changes from "unoccupied" to "occupied" immediately.
2) Room temperature is stable at unoccupied set point plus or minus 1.0 deg F within 30 minutes of occupancy.

3.5 AIR-HANDLING SYSTEM COMMISSIONING TESTS

A. Supply Fan(s) Variable-Volume Control:

1. Prerequisites: Installation verification of the following:

a. Volume Control Input Device: Static-pressure transmitter sensing supply-duct static pressure referenced to conditioned-space static pressure.
b. Volume Control Output Device: DDC system analog output to motor speed controller. Set variable-speed drive to minimum speed when fan is stopped.
c. High-Pressure Input Device: Static-pressure transmitter sensing supply-duct static pressure referenced to static pressure outside the duct.
d. High-Pressure Output Device: Receiver controller to motor speed controller.
e. Display the following in the BAS user interface:

1) Supply-fan-discharge static-pressure indication.
2) Supply-fan-discharge static-pressure set point.
3) Supply-fan airflow rate.
4) Supply-fan speed.

2. Conditions of the Test:

a. Minimum supply-air flow.
b. Midrange Supply-Air Flow: 50 to 60 percent of maximum.
c. Maximum supply-air flow.
d. Excess supply-air discharge static pressure.

3. Acceptance Criteria:

a. At all supply-air flow rates, and during changes in supply-air flow, discharge air static pressure is at set point plus or minus 2 percent.
b. Fan stops and an alarm is initiated in the BAS when supply-air discharge static pressure is at the excess static pressure plus or minus 2 percent.

END OF SECTION 230800

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 230923 - DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. DDC system for monitoring and controlling of HVAC systems.

B. Related Requirements:

1. Section 230923.22 "Position Instruments" for limit switches that connect to DDC systems.
2. Communications Cabling:

a. Section 260523 "Control-Voltage Electrical Power Cables" for balanced twisted pair communications cable.
b. Section 271513 "Communications Copper Horizontal Cabling" for balanced twisted pair communications cable.

3. Raceways:

a. Section 260533 "Raceways and Boxes for Electrical Systems" for raceways for low-voltage control cable.
b. Section 270528 "Pathways for Communications Systems" for raceways for balanced twisted pair cabling and optical fiber cable.

1.2 DEFINITIONS

A. Algorithm: A logical procedure for solving a recurrent mathematical problem. A prescribed set of well-defined rules or processes for solving a problem in a finite number of steps.

B. Analog: A continuously varying signal value, such as current, flow, pressure, or temperature.

C. BACnet Specific Definitions:

1. BACnet: Building Automation Control Network Protocol, ASHRAE 135. A communications protocol allowing devices to communicate data over and services over a network.
2. BACnet Interoperability Building Blocks (BIBBs): BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBs are combined to build the BACnet functional requirements for a device.
3. BACnet/IP: Defines and allows using a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet/IP network is a collection of one or more IP subnetworks that share the same BACnet network number.
4. BACnet Testing Laboratories (BTL): Organization responsible for testing products for compliance with ASHRAE 135, operated under direction of BACnet International.
5. PICS (Protocol Implementation Conformance Statement): Written document that identifies the particular options specified by BACnet that are implemented in a device.

D. Binary: Two-state signal where a high signal level represents ON" or "OPEN" condition and a low signal level represents "OFF" or "CLOSED" condition. "Digital" is sometimes used interchangeably with "Binary" to indicate a two-state signal.

E. Controller: Generic term for any standalone, microprocessor-based, digital controller residing on a network, used for local or global control. Three types of controllers are indicated: Network Controller and Programmable Application Controller.

F. Control System Integrator: An entity that assists in expansion of existing enterprise system and support of additional operator interfaces to I/O being added to existing enterprise system.

G. COV: Changes of value.

H. DDC System Provider: Authorized representative of, and trained by, DDC system manufacturer and responsible for execution of DDC system Work indicated.

I. Distributed Control: Processing of system data is decentralized and control decisions are made at subsystem level. System operational programs and information are provided to remote subsystems and status is reported back. On loss of communication, subsystems shall be capable of operating in a standalone mode using the last best available data.

J. DOCSIS: Data-Over Cable Service Interface Specifications.

K. Gateway: Bidirectional protocol translator that connects control systems that use different communication protocols.

L. HLC: Heavy load conditions.

M. I/O: System through which information is received and transmitted. I/O refers to analog input (AI), binary input (BI), analog output (AO) and binary output (BO). Analog signals are continuous and represent control influences such as flow, level, moisture, pressure, and temperature. Binary signals convert electronic signals to digital pulses (values) and generally represent two-position operating and alarm status. "Digital," (DI and (DO), is sometimes used interchangeably with "Binary," (BI) and (BO), respectively.

N. LAN: Local area network.

O. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

P. MS/TP: Master-slave/token-passing, IEE 8802-3. Datalink protocol LAN option that uses twisted-pair wire for low-speed communication.

Q. Network Controller: Digital controller, which supports a family of programmable application controllers, that communicates on peer-to-peer network for transmission of global data.

R. Network Repeater: Device that receives data packet from one network and rebroadcasts it to another network. No routing information is added to protocol.

S. Peer to Peer: Networking architecture that treats all network stations as equal partners.

T. POT: Portable operator's terminal.

U. RAM: Random access memory.

V. RF: Radio frequency.

W. Router: Device connecting two or more networks at network layer.

X. TCP/IP: Transport control protocol/Internet protocol..

Y. UPS: Uninterruptible power supply.

Z. USB: Universal Serial Bus.

AA. User Datagram Protocol (UDP): This protocol assumes that the IP is used as the underlying protocol.

BB. VAV: Variable air volume.

CC. WLED: White light emitting diode.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product include the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. When manufacturer's product datasheets apply to a product series rather than a specific product model, clearly indicate and highlight only applicable information.
5. Each submitted piece of product literature shall clearly cross reference specification and drawings that submittal is to cover.

B. Shop Drawings:

1. Schematic drawings for each controlled HVAC system indicating the following:

a. I/O points labeled with point names shown. Indicate instrument range, normal operating set points, and alarm set points. Indicate fail position of each damper and valve, if included in Project.
b. I/O listed in table format showing point name, type of device, manufacturer, model number, and cross-reference to product data sheet number.
c. A graphic showing location of control I/O in proper relationship to HVAC system.
d. Wiring diagram with each I/O point having a unique identification and indicating labels for all wiring terminals.
e. Unique identification of each I/O that shall be consistently used between different drawings showing same point.
f. Elementary wiring diagrams of controls for HVAC equipment motor circuits including interlocks, switches, relays and interface to DDC controllers.
g. Narrative sequence of operations

2. Control panel drawings indicating the following:

    a. Panel dimensions, materials, size, and location of field cable, raceways, and tubing connections.
    b. Interior subpanel layout, drawn to scale and showing all internal components, cabling and wiring raceways, nameplates and allocated spare space.
    c. Front, rear, and side elevations and nameplate legend.
    d. Unique drawing for each panel.

3. DDC system network riser diagram indicating the following:

    a. Each device connected to network with unique identification for each.
    b. Interconnection of each different network in DDC system.
    c. For each network, indicate communication protocol, speed and physical means of interconnecting network devices, such as copper cable type, or optical fiber cable type. Indicate raceway type and size for each.
    d. Each network port for connection of an operator workstation or other type of operator interface with unique identification for each.

4. Color graphics indicating the following:

    a. Itemized list of color graphic displays to be provided.
    b. For each display screen to be provided, a true color copy showing layout of pictures, graphics and data displayed.
    c. Intended operator access between related hierarchical display screens.

C. Delegated-Design Submittal: For DDC system products and installation indicated as being delegated.

1. Supporting documentation showing DDC system design complies with performance requirements indicated, including calculations and other documentation necessary to prove compliance.
2. Schedule and design calculations for control dampers and actuators.

    a. Flow at Project design and minimum flow conditions.
    b. Face velocity at Project design and minimum airflow conditions.
    c. Pressure drop across damper at Project design and minimum airflow conditions.
    d. AMCA 500-D damper installation arrangement used to calculate and schedule pressure drop, as applicable to installation.
    e. Maximum close-off pressure.
    f. Leakage airflow at maximum system pressure differential (fan close-off pressure).
    g. Torque required at worst case condition for sizing actuator.
    h. Actuator selection indicating torque provided.
    i. Actuator signal to control damper (on, close or modulate).
    j. Actuator position on loss of power.
    k. Actuator position on loss of control signal.

3. Schedule and design calculations for control valves and actuators.

    a. Flow at Project design and minimum flow conditions.
    b. Pressure-differential drop across valve at Project design flow condition.
    c. Maximum system pressure-differential drop (pump close-off pressure) across valve at Project minimum flow condition.

d. Design and minimum control valve coefficient with corresponding valve position.
e. Maximum close-off pressure.
f. Leakage flow at maximum system pressure differential.
g. Torque required at worst case condition for sizing actuator.
h. Actuator selection indicating torque provided.
i. Actuator signal to control damper (on, close or modulate).
j. Actuator position on loss of power.
k. Actuator position on loss of control signal.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For DDC system to include in emergency, operation and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format.
b. As-built versions of submittal Product Data.
c. Names, addresses, e-mail addresses and 24-hour telephone numbers of Installer and service representatives for DDC system and products.
d. Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.
e. Backup copy of graphic files, programs, and database on electronic media such as DVDs or removable drives.
f. List of recommended spare parts with part numbers and suppliers.
g. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
h. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.
i. Licenses, guarantees, and warranty documents.
j. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
k. Owner training materials.

1.5 QUALITY ASSURANCE

A. Controls provided within this partial remodel project shall be Delta to match the existing Pima County installation.

1.6 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace products that fail in materials or workmanship within specified warranty period.

1. Failures shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner.
2. Include updates or upgrades to software and firmware if necessary to resolve deficiencies.

a. Install updates only after receiving Owner's written authorization.

3. Warranty service shall occur during normal business hours and commence within 24 hours of Owner's warranty service request.
4. Warranty Period: Two year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 DDC SYSTEM MANUFACTURERS

A. Subject to compliance with the requirements, provide HVAC controls system by the following:

1. Delta BACnet Controls to match existing campus network

2.2 DDC SYSTEM DESCRIPTION

A. Microprocessor-based monitoring and control including analog/digital conversion and program logic. A control loop or subsystem in which digital and analog information is received and processed by a microprocessor, and digital control signals are generated based on control algorithms and transmitted to field devices to achieve a set of predefined conditions.

1. DDC system shall consist of a high-speed, peer-to-peer network of distributed DDC controllers, operator interfaces, and software.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional to design DDC system to satisfy requirements indicated.

1. System Performance Objectives:

a. DDC system shall manage HVAC systems.
b. DDC system control shall operate HVAC systems to achieve optimum operating costs while using least possible energy and maintaining specified performance.
c. DDC system shall respond to power failures, HVAC equipment failures, and adverse and emergency conditions encountered through connected I/O points.
d. DDC system shall operate while unattended by an operator and through operator interaction.
e. DDC system shall record trends and transaction of events and produce report information such as performance, energy, occupancies, and equipment operation.

B. Surface-Burning Characteristics: Products installed in ducts, equipment, and return-air paths shall comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 50 or less.

C. DDC System Speed:

1. Response Time of Connected I/O:

a. AI point values connected to DDC system shall be updated at least every five seconds for use by DDC controllers. Points used globally shall also comply with this requirement.
b. BI point values connected to DDC system shall be updated at least every five seconds for use by DDC controllers. Points used globally shall also comply with this requirement.
c. AO points connected to DDC system shall begin to respond to controller output commands within two second(s). Global commands shall also comply with this requirement.
d. BO point values connected to DDC system shall respond to controller output commands within two second(s). Global commands shall also comply with this requirement.

2. Display of Connected I/O:

a. Analog point COV connected to DDC system shall be updated and displayed at least every 10 seconds for use by operator.
b. Binary point COV connected to DDC system shall be updated and displayed at least every 10 seconds for use by operator.
c. Alarms of analog and digital points connected to DDC system shall be displayed within 45 seconds of activation or change of state.
d. Graphic display refresh shall update within eight seconds.
e. Point change of values and alarms displayed from workstation to workstation when multiple operators are viewing from multiple workstations shall not exceed graphic refresh rate indicated.

D. Network Bandwidth: Design each network of DDC system to include at least 30 percent available spare bandwidth with DDC system operating under normal and heavy load conditions indicated. Calculate bandwidth usage, and apply a safety factor to ensure that requirement is satisfied when subjected to testing under worst case conditions.

E. Input Point Displayed Accuracy: Input point displayed values shall meet following end-to-end overall system accuracy, including errors associated with meter, sensor, transmitter, lead wire or cable, and analog to digital conversion.

1. Gas:

a. Carbon Dioxide: Within 30 ppm.

2. Moisture (Relative Humidity):

a. Air: Within 2 percent RH.
b. Outdoor: Within 2 percent RH.

3. Pressure:

a. Air, Ducts and Equipment: 0.5 percent of instrument range.
b. Space: Within 0.25 percent of instrument range.
c. Water: Within 0.25 percent of instrument range.

4. Temperature, Dry Bulb:

    a. Air: Within 0.5 deg F.
    b. Space: Within 1 deg F.
    c. Chilled Water: Within 1 deg F.
    d. Heating Hot Water: Within 1 deg F.

5. Temperature, Wet Bulb:

    a. Air: Within 0.5 deg F.
    b. Space: Within 1 deg F.

F. Precision of I/O Reported Values: Values reported in database and displayed shall have following precision:

1. Current:

    a. Milliamperes: Nearest 1/100th of a milliampere.
    b. Amperes: Nearest 1/10th of an ampere up to 100 A; nearest ampere for 100 A and more.

2. Energy:

    a. Electric Power:

        1) Rate (Watts): Nearest 1/10th of a watt through 1000 W.
        2) Rate (Kilowatts): Nearest 1/10th of a kilowatt through 1000 kW; nearest kilowatt above 1000 kW.
        3) Usage (Kilowatt-Hours): Nearest kilowatt through 10,000 kW; nearest 10 kW between 10,000 and 100,000 kW; nearest 100 kW for above 100,000 kW.

3. Flow:

    a. Air: Nearest 1/10th of a cfm through 100 cfm; nearest cfm between 100 and 1000 cfm; nearest 10 cfm between 1000 and 10,000 cfm; nearest 100 cfm above 10,000 cfm.
    b. Water: Nearest 1/10th gpm through 100 gpm; nearest gpm between 100 and 1000 gpm; nearest 10 gpm between 1000 and 10,000 gpm; nearest 100 gpm above 10,000 gpm.

4. Gas:

    a. Carbon Dioxide (ppm): Nearest ppm.

5. Moisture (Relative Humidity):

    a. Relative Humidity (Percentage): Nearest 1 percent.

6. Position, Dampers and Valves (Percentage Open): Nearest 1 percent.
7. Pressure:

    a. Air, Ducts and Equipment: Nearest 1/10th in. w.c..
    b. Space: Nearest 1/100th in. w.c. .

c. Water: Nearest 1/10 psig through 100 psig, nearest psig above 100 psig.

8. Temperature:

a. Air, Ducts and Equipment: Nearest 1/10th of a degree.
b. Outdoor: Nearest degree.
c. Space: Nearest 1/10th of a degree.
d. Chilled Water: Nearest 1/10th of a degree.
e. Heating Hot Water: Nearest degree.

9. Voltage: Nearest 1/10 volt up to 100 V; nearest volt above 100 V.

G. Environmental Conditions for Controllers, Gateways, and Routers:

1. Products shall operate without performance degradation under ambient environmental temperature, pressure and humidity conditions encountered for installed location.

a. If product alone cannot comply with requirement, install product in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated, cooled and ventilated as required by product and application.

2. Products shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Products not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Installed location shall dictate the following NEMA 250 enclosure requirements:

a. Outdoors, Protected: Type 2.
b. Outdoors, Unprotected: Type 4.
c. Indoors, Heated with Filtered Ventilation: Type 1.
d. Indoors, Heated with Non-Filtered Ventilation: Type 2.
e. Indoors, Heated and Air Conditioned: Type 1.
f. Mechanical Equipment Rooms:
   1) Air-Moving Equipment Rooms: Type 1.
g. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: Type 2.
h. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: Type 4.
i. Hazardous Locations: Explosion-proof rating for condition.

H. Environmental Conditions for Instruments and Actuators:

1. Instruments and actuators shall operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.

a. If instruments and actuators alone cannot comply with requirement, install instruments and actuators in protective enclosures that are isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated, cooled and ventilated as required by instrument and application.

2. Instruments, actuators and accessories shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Instruments and actuators not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Installed location shall dictate the following NEMA 250 enclosure requirements:

    a. Outdoors, Protected: Type 2.
    b. Outdoors, Unprotected: Type 4.
    c. Indoors, Heated with Filtered Ventilation: Type 1.
    d. Indoors, Heated with Non-Filtered Ventilation: Type 2.
    e. Indoors, Heated and Air-conditioned: Type 1.
    f. Mechanical Equipment Rooms:
        1) Air-Moving Equipment Rooms: Type 1.
    g. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation:Type 2.
    h. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: Type 4.
    i. Hazardous Locations: Explosion-proof rating for condition.

I. Electric Power Quality:

1. Power-Line Surges:

    a. Protect DDC system products connected to ac power circuits from power-line surges to comply with requirements of IEEE C62.41.
    b. Do not use fuses for surge protection.
    c. Test protection in the normal mode and in the common mode, using the following two waveforms:

        1) 10-by-1000-mic.sec. waveform with a peak voltage of 1500 V and a peak current of 60 A.
        2) 8-by-20-mic.sec. waveform with a peak voltage of 1000 V and a peak current of 500 A.

2. Power Conditioning:

    a. Protect DDC system products connected to ac power circuits from irregularities and noise rejection. Characteristics of power-line conditioner shall be as follows:

        1) At 85 percent load, output voltage shall not deviate by more than plus or minus 1 percent of nominal when input voltage fluctuates between minus 20 percent to plus 10 percent of nominal.
        2) During load changes from zero to full load, output voltage shall not deviate by more than plus or minus 3 percent of nominal.
        3) Accomplish full correction of load switching disturbances within five cycles, and 95 percent correction within two cycles of onset of disturbance.
        4) Total harmonic distortion shall not exceed 3-1/2 percent at full load.

3. Ground Fault: Protect products from ground fault by providing suitable grounding. Products shall not fail due to ground fault condition.

J. Backup Power Source:

1. HVAC systems and equipment served by a backup power source shall have associated DDC system products that control such systems and equipment also served from a backup power source.

K. UPS:

1. DDC system products powered by UPS units shall include the following:
   a. Servers.
   b. Gateways.
   c. DDC controllers.

2. DDC system instruments and actuators powered by UPS units shall include the following:

   a. Instruments associated with the following systems controlled by DDC system:

      1) Central Station Air Handling Units.

   b. Dampers and actuators associated with the following systems controlled by DDC system:

      1) Central Station Air Handling Units.

   c. Valves and actuators associated with the following systems controlled by DDC system:

      1) Central Station Air Handling Units.

2.4 SYSTEM ARCHITECTURE

A. Minimum Data Transfer and Communication Speed:

1. LAN Connecting Operator Workstations and Network Controllers: 100 Mbps.
2. LAN Connecting Programmable Application Controllers: 1000 kbps.

B. DDC system shall consist of dedicated LANs that are not shared with other building systems and tenant data and communication networks.

C. System architecture shall be modular and have inherent ability to expand to not less than three times system size indicated with no impact to performance indicated.

D. System architecture shall perform modifications without having to remove and replace existing network equipment.

E. Number of LANs and associated communication shall be transparent to operator. All I/O points residing on any LAN shall be capable of global sharing between all system LANs.

F. System design shall eliminate dependence on any single device for system alarm reporting and control execution. Each controller shall operate independently by performing its' own control, alarm management and historical data collection.

G. Special Network Architecture Requirements:

1. Air-Handling Systems: For control applications of an air-handling system that consists of air-handling unit(s) and VAV terminal units, include a dedicated LAN of programmable application controllers serving VAV terminal units connected directly to controller that is controlling air-handling system air-handling unit(s). Basically, create a DDC system LAN that aligns with air-handling system being controlled.

2.5 DDC SYSTEM OPERATOR INTERFACES

A. Operator Means of System Access: Operator shall be able to access entire DDC system through any of multiple means, including, but not limited to, the following:

1. Desktop and portable workstation with hardwired connection through LAN port.
2. Portable operator terminal with hardwired connection through LAN port.

B. Access to system, regardless of operator means used, shall be transparent to operator.

C. Network Ports: For hardwired connection of desktop or portable workstation. Network port shall be easily accessible, properly protected, clearly labeled, and installed at the following locations:

1. Each mechanical equipment room.
2. Each terminal unit controller or associated thermostat

D. Critical Alarm Reporting:

1. Operator-selected critical alarms shall be sent by DDC system to notify operator of critical alarms that require immediate attention.
2. DDC system shall send alarm notification to multiple recipients that are assigned for each alarm.
3. DDC system shall notify recipients by any or all means, including e-mail, text message, and prerecorded phone message to mobile and landline phone numbers.

E. Simultaneous Operator Use: Capable of accommodating up to 20 simultaneous operators that are accessing DDC system through any one of operator interfaces indicated.

2.6 NETWORK COMMUNICATION PROTOCOL

A. Network communication protocol(s) used throughout entire DDC system shall be open to Owner and available to other companies for use in making future modifications to DDC system.

B. ASHRAE 135 Protocol:

1. ASHRAE 135 communication protocol shall be sole and native protocol used throughout entire DDC system.
2. DDC system shall not require use of gateways except to integrate HVAC equipment and other building systems and equipment, not required to use ASHRAE 135 communication protocol.
3. If used, gateways shall connect to DDC system using ASHRAE 135 communication protocol and Project object properties and read/write services indicated by interoperability schedule.
4. Controllers and other network devices shall be tested and listed by BACnet Testing Laboratories.

2.7 DDC CONTROLLERS

A. DDC system shall consist of a combination of network controllers and programmable application controllers to satisfy performance requirements indicated.

B. DDC controllers shall perform monitoring, control, energy optimization and other requirements indicated.

C. DDC controllers shall use a multitasking, multiuser, real-time digital control microprocessor with a distributed network database and intelligence.

D. Each DDC controller shall be capable of full and complete operation as a completely independent unit and as a part of a DDC system wide distributed network.

E. Environment Requirements:

1. Controller hardware shall be suitable for the anticipated ambient conditions.
2. Controllers located in conditioned space shall be rated for operation at 32 to 120 deg F.
3. Controllers located outdoors shall be rated for operation at 40 to 150 deg F.

F. Power and Noise Immunity:

1. Controller shall operate at 90 to 110 percent of nominal voltage rating and shall perform an orderly shutdown below 80 percent of nominal voltage.
2. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios with up to 5 W of power located within 36 inches of enclosure.

G. DDC Controller Spare Processing Capacity:

1. Include spare processing memory for each controller. RAM, PROM, or EEPROM will implement requirements indicated with the following spare memory:

a. Network Controllers: 50 percent.
b. Programmable Application Controllers: Not less than 60 percent.

2. Memory shall support DDC controller's operating system and database and shall include the following:

a. Monitoring and control.
b. Energy management, operation and optimization applications.
c. Alarm management.
d. Historical trend data of all connected I/O points.
e. Maintenance applications.
f. Operator interfaces.
g. Monitoring of manual overrides.

H. DDC Controller Spare I/O Point Capacity: Include spare I/O point capacity for each controller as follows:

1. Network Controllers:

a. 20 percent of each AI, AO, BI, and BO point connected to controller.
b. Minimum Spare I/O Points per Controller:

1) AIs: Three.

2) AOs: Two.
3) BIs: Five.
4) BOs: Three.

2. Programmable Application Controllers:

a. 20 percent of each AI, AO, BI, and BO point connected to controller.
b. Minimum Spare I/O Points per Controller:

1) AIs: Three.
2) AOs: Two.
3) BIs: Five.
4) BOs: Three.

3. Application-Specific Controllers:

a. 10 percent of each AI, AO, BI, and BO point connected to controller.
b. Minimum Spare I/O Points per Controller:

1) AIs: Two.
2) AOs: Two.
3) BIs: Two.
4) BOs: Two.

I. Maintenance and Support: Include the following features to facilitate maintenance and support:

1. Mount microprocessor components on circuit cards for ease of removal and replacement.
2. Means to quickly and easily disconnect controller from network.
3. Means to quickly and easily access connect to field test equipment.
4. Visual indication that controller electric power is on, of communication fault or trouble, and that controller is receiving and sending signals to network.

J. Input and Output Point Interface:

1. Hardwired input and output points shall connect to network, programmable application controllers.
2. Input and output points shall be protected so shorting of point to itself, to another point, or to ground will not damage controller.
3. Input and output points shall be protected from voltage up to 24 V of any duration so that contact will not damage controller.
4. AIs:

a. AIs shall include monitoring of low-voltage (zero- to 10-V dc), current (4 to 20 mA) and resistance signals from thermistor and RTD sensors.
b. AIs shall be compatible with, and field configurable to, sensor and transmitters installed.
c. Controller AIs shall perform analog-to-digital (A-to-D) conversion with a minimum resolution of 8 bits or better to comply with accuracy requirements indicated.
d. Signal conditioning including transient rejection shall be provided for each AI.
e. Capable of being individually calibrated for zero and span.
f. Incorporate common-mode noise rejection of at least 50 dB from zero to 100 Hz for differential inputs, and normal-mode noise rejection of at least 20 dB at 60 Hz from a source impedance of 10000 ohms.

5. AOs:

   a. Controller AOs shall perform analog-to-digital (A-to-D) conversion with a minimum resolution of 8 bits or better to comply with accuracy requirements indicated.
   b. Output signals shall have a range of 4 to 20 mA dc or zero- to 10-V dc as required to include proper control of output device.
   c. Capable of being individually calibrated for zero and span.
   d. AOs shall not exhibit a drift of greater than 0.4 percent of range per year.

6. BIs:

   a. Controller BIs shall accept contact closures and shall ignore transients of less than 5-ms duration.
   b. Isolation and protection against an applied steady-state voltage of up to 180-V ac peak.
   c. BIs shall include a wetting current of at least 12 mA to be compatible with commonly available control devices and shall be protected against effects of contact bounce and noise.
   d. BIs shall sense "dry contact" closure without external power (other than that provided by the controller) being applied.
   e. Pulse accumulation input points shall comply with all requirements of BIs and accept up to 10 pulses per second for pulse accumulation. Buffer shall be provided to totalize pulses. Pulse accumulator shall accept rates of at least 20 pulses per second. The totalized value shall be reset to zero on operator's command.

7. BOs:

   a. Controller BOs shall include relay contact closures or triac outputs for momentary and maintained operation of output devices.

      1) Relay contact closures shall have a minimum duration of 0.1 second. Relays shall include at least 180 V of isolation. Electromagnetic interference suppression shall be provided on all output lines to limit transients to non-damaging levels. Minimum contact rating shall be 1 A at 24-V ac.
      2) Triac outputs shall include at least 180 V of isolation. Minimum contact rating shall be 1 A at 24-V ac.

   b. BOs shall include for two-state operation or a pulsed low-voltage signal for pulse-width modulation control.
   c. BOs shall be selectable for either normally open or normally closed operation.
   d. Include tristate outputs (two coordinated BOs) for control of three-point floating-type electronic actuators without feedback.
   e. Limit use of three-point floating devices to VAV terminal unit control applications,. Control algorithms shall operate actuator to one end of its stroke once every 24 hours for verification of operator tracking.

2.8 NETWORK CONTROLLERS

A. General Network Controller Requirements:

1. Include adequate number of controllers to achieve performance indicated.
2. System shall consist of one or more independent, standalone, microprocessor-based network controllers to manage global strategies indicated.

3. Controller shall have enough memory to support its operating system, database, and programming requirements.
4. Data shall be shared between networked controllers and other network devices.
5. Operating system of controller shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
6. Controllers shall have a real-time clock.
7. Controller shall continually check status of its processor and memory circuits. If an abnormal operation is detected, controller shall assume a predetermined failure mode and generate an alarm notification.
8. Controllers shall be fully programmable.

B. Communication:

1. Network controllers shall communicate with other devices on DDC system Level one network.
2. Network controller also shall perform routing if connected to a network of programmable application controllers.

C. Operator Interface:

1. Controller shall be equipped with a service communications port for connection to a portable operator's workstation.
2. Local Keypad and Display:

   a. Equip controller with local keypad and digital display for interrogating and editing data.
   b. Use of keypad and display shall require security password.

D. Serviceability:

1. Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Controller shall maintain BIOS and programming information in event of a power loss for at least 72 hours.

2.9 PROGRAMMABLE APPLICATION CONTROLLERS

A. General Programmable Application Controller Requirements:

1. Include adequate number of controllers to achieve performance indicated.
2. Controller shall have enough memory to support its operating system, database, and programming requirements.
3. Data shall be shared between networked controllers and other network devices.
4. Operating system of controller shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
5. Controllers shall have a real-time clock.
6. Controller shall continually check status of its processor and memory circuits. If an abnormal operation is detected, controller shall assume a predetermined failure mode and generate an alarm notification.
7. Controllers shall be fully programmable.

B. Communication:

1. Programmable application controllers shall communicate with other devices on network.

C. Operator Interface:

1. Controller shall be equipped with a service communications port for connection to a portable operator's workstation.

D. Serviceability:

1. Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Controller shall maintain BIOS and programming information in event of a power loss for at least 72 hours.

2.10 APPLICATION-SPECIFIC CONTROLLERS

A. Description: Microprocessor-based controllers, which through hardware or firmware design are dedicated to control a specific piece of equipment. Controllers are not fully user-programmable but are configurable and customizable for operation of equipment they are designed to control.

1. Capable of standalone operation and shall continue to include control functions without being connected to network.
2. Data shall be shared between networked controllers and other network devices.

B. Communication: Application-specific controllers shall communicate with other application-specific controller and devices on network, and to programmable application and network controllers.

C. Operator Interface: Controller shall be equipped with a service communications port for connection to a portable operator's workstation.

D. Serviceability:

1. Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Controller shall use nonvolatile memory and maintain all BIOS and programming information in event of power loss.

2.11 CONTROLLER SOFTWARE

A. General Controller Software Requirements:

1. Software applications shall reside and operate in controllers. Editing of applications shall occur at operator workstations.

2. I/O points shall be identified by up to 30-character point name and up to 16-character point descriptor. All point naming conventions shall match that of the existing campus network.
3. Control functions shall be executed within controllers using DDC algorithms.
4. Controllers shall be configured to use stored default values to ensure fail-safe operation. Default values shall be used when there is a failure of a connected input instrument or loss of communication of a global point value.

B. Security:

1. Operator access shall be secured using individual security passwords and user names.
2. Passwords shall restrict operator to points, applications, and system functions as assigned by system manager.
3. Operator log-on and log-off attempts shall be recorded.
4. System shall protect itself from unauthorized use by automatically logging off after last keystroke. The delay time shall be operator-definable.

C. Scheduling: Include capability to schedule each point or group of points in system. Each schedule shall consist of the following:

1. Weekly Schedule:

a. Include separate schedules for each day of week.
b. Each schedule should include the capability for start, stop, optimal start, optimal stop, and night economizer.
c. Each schedule may consist of up to 10 events.
d. When a group of objects are scheduled together, include capability to adjust start and stop times for each member.

2. Exception Schedules:

a. Include ability for operator to designate any day of the year as an exception schedule.
b. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed, it will be discarded and replaced by regular schedule for that day of week.

3. Holiday Schedules:

a. Include capability for operator to define up to 99 special or holiday schedules.
b. Schedules may be placed on scheduling calendar and will be repeated each year.
c. Operator shall be able to define length of each holiday period.

D. System Coordination:

1. Include standard application for proper coordination of equipment.
2. Application shall include operator with a method of grouping together equipment based on function and location.
3. Group may then be used for scheduling and other applications.

E. Binary Alarms:

1. Each binary point shall be set to alarm based on operator-specified state.
2. Include capability to automatically and manually disable alarming.

F. Analog Alarms:

1. Each analog object shall have both high and low alarm limits.
2. Alarming shall be able to be automatically and manually disabled.

G. Alarm Reporting:

1. Operator shall be able to determine action to be taken in event of an alarm.
2. Alarms shall be routed to appropriate operator workstations based on time and other conditions.
3. Alarm shall be able to start programs, print, be logged in event log, generate custom messages, and display graphics.

H. Sequencing: Include application software based on sequences of operation indicated to properly sequence applicable HVAC equipment.

I. Control Loops:

1. Support any of the following control loops, as applicable to control required:

a. Two-position (on/off, open/close, slow/fast) control.
b. Proportional control.
c. Proportional plus integral (PI) control.
d. Proportional plus integral plus derivative (PID) control.

1) Include PID algorithms with direct or reverse action and anti-windup.
2) Algorithm shall calculate a time-varying analog value used to position an output or stage a series of outputs.
3) Controlled variable, set point, and PID gains shall be operator-selectable.

e. Adaptive (automatic tuning).

J. Staggered Start: Application shall prevent all controlled equipment from simultaneously restarting after a power outage. Order which equipment (or groups of equipment) is started, along with the time delay between starts, shall be operator-selectable.

K. Energy Calculations:

1. Include software to allow instantaneous power or flow rates to be accumulated and converted to energy usage data.
2. Include an algorithm that calculates a sliding-window average (rolling average). Algorithm shall be flexible to allow window intervals to be operator specified (such as 15, 30, or 60 minutes).
3. Include an algorithm that calculates a fixed-window average. A digital input signal shall define start of window period (such as signal from utility meter) to synchronize fixed-window average with that used by utility.

L. Anti-Short Cycling:

1. BO points shall be protected from short cycling.
2. Feature shall allow minimum on-time and off-time to be selected.

M. On and Off Control with Differential:

1. Include an algorithm that allows a BO to be cycled based on a controlled variable and set point.
2. Algorithm shall be direct- or reverse-acting and incorporate an adjustable differential.

N. Run-Time Totalization:

1. Include software to totalize run-times for all BI points.
2. A high run-time alarm shall be assigned, if required, by operator.

2.12 ENCLOSURES

A. General Enclosure Requirements:

1. House each controller and associated control accessories in an enclosure. Enclosure shall serve as central tie-in point for control devices such as switches, transmitters, transducers, power supplies and transformers.
2. Do not house more than one controller in a single enclosure.
3. Include enclosure door with key locking mechanism. Key locks alike for all enclosures and include one pair of keys per enclosure.
4. Include wall-mounted enclosures with brackets suitable for mounting enclosures to wall or freestanding support stand as indicated.
5. Supply each enclosure with a complete set of as-built schematics, tubing, and wiring diagrams and product literature located in a pocket on inside of door.

B. Internal Arrangement:

1. Internal layout of enclosure shall group and protect pneumatic, electric, and electronic components associated with a controller, but not an integral part of controller.
2. Arrange layout to group similar products together.
3. Include a barrier between line-voltage and low-voltage electrical and electronic products.
4. Factory or shop install products, tubing, cabling and wiring complying with requirements and standards indicated.
5. Terminate field cable and wire using heavy-duty terminal blocks.
6. Include spare terminals, equal to not less than 10 percent of used terminals.
7. Include spade lugs for stranded cable and wire.
8. Install a maximum of two wires on each side of a terminal.
9. Include enclosure field power supply with a toggle-type switch located at entrance inside enclosure to disconnect power.
10. For major HVAC equipment controllers, include enclosure with a line-voltage nominal 20-A GFCI duplex receptacle for service and testing tools. Wire receptacle on hot side of enclosure disconnect switch and include with a 5-A circuit breaker.
11. Mount products within enclosure on removable internal panel(s).
12. Route tubing cable and wire located inside enclosure within a raceway with a continuous removable cover.
13. Label each end of cable, wire and tubing in enclosure following an approved identification system that extends from field I/O connection and all intermediate connections throughout length to controller connection.
14. Size enclosure internal panel to include at least 25 percent spare area on face of panel.

C. Environmental Requirements:

1. Evaluate temperature and humidity requirements of each product to be installed within each enclosure.
2. Calculate enclosure internal operating temperature considering heat dissipation of all products installed within enclosure and ambient effects (solar, conduction and wind) on enclosure.
3. Where required by application, include temperature-controlled electrical heat to maintain inside of enclosure above minimum operating temperature of product with most stringent requirement.
4. Where required by application, include temperature-controlled ventilation fans with filtered louver(s) to maintain inside of enclosure below maximum operating temperature of product with most stringent requirement.

D. Wall-Mounted, NEMA 250, Type 1:

1. Enclosure shall be NRTL listed according to UL 50 or UL 50E.

2. Construct enclosure of steelFinish enclosure inside and out with polyester powder coating that is electrostatically applied and then baked to bond to substrate.

3. Hinged door full size of front face of enclosure and supported using:

   a. Enclosures sizes less than 36 in. tall: Multiple butt hinges.
   b. Enclosures sizes 36 in. tall and larger: Continuous piano hinges.

4. Removable internal panel with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.

   a. Size less than 24 in.: Solid or Perforated steel, 0.053 in. thick.
   b. Size 24 in. and larger: Solid aluminum, 0.10 in. thick.

5. Internal panel mounting hardware, grounding hardware and sealing washers.
6. Grounding stud on enclosure body.
7. Thermoplastic pocket on inside of door for record Drawings and Product Data.

E. Wall Mounted NEMA 250, Types 4 and 12:

1. Enclosure shall be NRTL listed according to UL 508A.
2. Seam and joints are continuously welded and ground smooth.
3. Where recessed enclosures are indicated, include enclosures with face flange for flush mounting.
4. Externally formed body flange around perimeter of enclosure face for continuous perimeter seamless gasket door seal.
5. Single-door enclosure sizes up to 60 inches tall by 36 inches wide.
6. Double-door enclosure sizes up to 36 inches tall by 60 inches wide.
7. Construct enclosure of steel.

8. Corner-formed door, full size of enclosure face, supported using multiple concealed hinges with easily removable hinge pins.

   a. Sizes through 24 Inches Tall: Two hinges.
   b. Sizes between 24 Inches through 48 Inches Tall: Three hinges.
   c. Sizes Larger 48 Inches Tall: Four hinges.

9. Double-door enclosures with overlapping door design to include unobstructed full-width access.

    a. Single-door enclosures 48 inches and taller, and all double-door enclosures, with three-point (top, middle and bottom) latch system.

10. Removable internal panel with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.

    a. Size Less Than 24 Inches: Solid or perforated steel, 0.053 inch thick.
    b. Size 24 Inches and Larger: Solid aluminum, 0.10 inch thick.

11. Internal panel mounting studs with hardware, grounding hardware, and sealing washers.
12. Grounding stud on enclosure body.
13. Thermoplastic pocket on inside of door for record Drawings and Product Data.

F. Accessories:

1. Bar handle with keyed cylinder lock set.

2.13 RELAYS

A. General-Purpose Relays:
1. Relays shall be heavy duty and rated for at least 10 A at 250-V ac and 60 Hz.
2. Relays shall be either double pole double throw (DPDT) or three-pole double throw, depending on the control application.
3. Use a plug-in-style relay with an eight-pin octal plug for DPDT relays and an 11-pin octal plug for three-pole double-throw relays.
4. Construct the contacts of either silver cadmium oxide or gold.
5. Enclose the relay in a clear transparent polycarbonate dust-tight cover.
6. Relays shall have LED indication and a manual reset and push-to-test button.
7. Performance:

    a. Mechanical Life: At least 10 million cycles.
    b. Electrical Life: At least 100,000 cycles at rated load.
    c. Pickup Time: 15 ms or less.
    d. Dropout Time: 10 ms or less.
    e. Pull-in Voltage: 85 percent of rated voltage.
    f. Dropout Voltage: 50 percent of nominal rated voltage.
    g. Power Consumption: 2 VA.
    h. Ambient Operating Temperatures: Minus 40 to 115 deg F.

8. Equip relays with coil transient suppression to limit transients to non-damaging levels.
9. Plug each relay into an industry-standard, 35-mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
10. Relay socket shall have screw terminals. Mold into the socket the coincident screw terminal numbers and associated octal pin numbers.

B. Multifunction Time-Delay Relays:

1. Relays shall be continuous duty and rated for at least 10 A at 240-V ac and 60 Hz.
2. Relays shall be DPDT relay with up to eight programmable functions to provide on/off delay, interval and recycle timing functions.

3. Use a plug-in-style relay with either an 8- or 11-pin octal plug.
4. Construct the contacts of either silver cadmium oxide or gold.
5. Enclose the relay in a dust-tight cover.
6. Include knob and dial scale for setting delay time.
7. Performance:

    a. Mechanical Life: At least 10 million cycles.
    b. Electrical Life: At least 100,000 cycles at rated load.
    c. Timing Ranges: Multiple ranges from 0.1 seconds to 100 minutes.
    d. Repeatability: Within 2 percent.
    e. Recycle Time: 45 ms.
    f. Minimum Pulse Width Control: 50 ms.
    g. Power Consumption: 5 VA or less at 120-V ac.
    h. Ambient Operating Temperatures: Minus 40 to 115 deg F.

8. Equip relays with coil transient suppression to limit transients to non-damaging levels.
9. Plug each relay into an industry-standard, 35-mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
10. Relay socket shall have screw terminals. Mold into the socket the coincident screw terminal numbers and associated octal pin numbers.

C. Latching Relays:

1. Relays shall be continuous duty and rated for at least 10 A at 250-V ac and 60 Hz.
2. Relays shall be either DPDT or three-pole double throw, depending on the control application.
3. Use a plug-in-style relay with a multibladed plug.
4. Construct the contacts of either silver cadmium oxide or gold.
5. Enclose the relay in a clear transparent polycarbonate dust-tight cover.
6. Performance:

    a. Mechanical Life: At least 10 million cycles.
    b. Electrical Life: At least 100,000 cycles at rated load.
    c. Pickup Time: 15 ms or less.
    d. Dropout Time: 10 ms or less.
    e. Pull-in Voltage: 85 percent of rated voltage.
    f. Dropout Voltage: 50 percent of nominal rated voltage.
    g. Power Consumption: 2 VA.
    h. Ambient Operating Temperatures: Minus 40 to 115 deg F.

7. Equip relays with coil transient suppression to limit transients to non-damaging levels.
8. Plug each relay into an industry-standard, 35-mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
9. Relay socket shall have screw terminals. Mold into the socket the coincident screw terminal numbers and associated octal pin numbers.

D. Current Sensing Relay:

1. Monitors ac current.
2. Independent adjustable controls for pickup and dropout current.
3. Energized when supply voltage is present and current is above pickup setting.
4. De-energizes when monitored current is below dropout current.
5. Dropout current is adjustable from 50 to 95 percent of pickup current.
6. Include a current transformer, if required for application.
7. House current sensing relay and current transformer in its own enclosure. Use NEMA 250, Type 12 enclosure for indoors and NEMA 250, Type 4 for outdoors.

E. Combination On-Off Status Sensor and On-Off Relay:

1. Description:

a. On-off control and status indication in a single device.
b. LED status indication of activated relay and current trigger.
c. Closed-Open-Auto override switch located on the load side of the relay.

2. Performance:

a. Ambient Temperature: Minus 30 to 140 deg F.
b. Voltage Rating: Single-phase loads rated for 300-V ac. Three-phase loads rated for 600-V ac.

3. Status Indication:

a. Current Sensor: Integral sensing for single-phase loads up to 20 A and external solid or split sensing ring for three-phase loads up to 150 A.
b. Current Sensor Range: As required by application.
c. Current Set Point: Fixed or adjustable as required by application.

4. Relay: Single-pole double-throw, continuous-duty coil; rated for 10-million mechanical cycles.
5. Enclosure: NEMA 250, Type 1 enclosure.

2.14 ELECTRICAL POWER DEVICES

A. Transformers:

1. Transformer shall be sized for the total connected load, plus an additional 25 percent of connected load.
2. Transformer shall have both primary and secondary fuses.

B. DC Power Supply:

1. Plug-in style suitable for mating with a standard eight-pin octal socket. Include the power supply with a mating mounting socket.
2. Enclose circuitry in a housing.
3. Include both line and load regulation to ensure a stable output. To protect both the power supply and the load, power supply shall have an automatic current limiting circuit.
4. Performance:

a. Output voltage nominally 25-V dc within 5 percent.
b. Output current up to 100 mA.
c. Input voltage nominally 120-V ac, 60 Hz.
d. Load regulation within 0.5 percent from zero- to 100-mA load.
e. Line regulation within 0.5 percent at a 100-mA load for a 10 percent line change.
f. Stability within 0.1 percent of rated volts for 24 hours after a 20-minute warmup.

2.15 CONTROL WIRE AND CABLE

A. Wire: Single conductor control wiring above 24 V.

1. Wire size shall be at least No. 16 AWG.

2. Conductor shall be 7/24 soft annealed copper strand with 2- to 2.5-inch lay.
3. Conductor insulation shall be 600 V, Type THWN or Type THHN, and 90 deg C according to UL 83.
4. Conductor colors shall be black (hot), white (neutral), and green (ground).
5. Furnish wire on spools.

B. Single Twisted Shielded Instrumentation Cable above 24 V:

1. Wire size shall be a minimum No. 18 AWG.
2. Conductors shall be a twisted, 7/24 soft annealed copper strand with a 2- to 2.5-inch lay.
3. Conductor insulation shall have a Type THHN/THWN or Type TFN rating.
4. Shielding shall be 100 percent type, 0.35/0.5-mil aluminum/Mylar tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
5. Outer jacket insulation shall have a 600-V, 90-deg C rating and shall be Type TC cable.
6. For twisted pair, conductor colors shall be black and white. For twisted triad, conductor colors shall be black, red and white.
7. Furnish wire on spools.

C. Single Twisted Shielded Instrumentation Cable 24 V and Less:

1. Wire size shall be a minimum No. 18 AWG.
2. Conductors shall be a twisted, 7/24 soft annealed copper stranding with a 2- to 2.5-inch lay.
3. Conductor insulation shall have a nominal 15-mil thickness, constructed from flame-retardant PVC.
4. Shielding shall be 100 percent type, 1.35-mil aluminum/polymer tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
5. Outer jacket insulation shall have a 300-V, 105-deg C rating and shall be Type PLTC cable.
6. For twisted pair, conductor colors shall be black and white. For twisted triad, conductor colors shall be black, red and white.
7. Furnish wire on spools.

D. LAN and Communication Cable: Comply with DDC system manufacturer requirements for network being installed.

1. Cable shall be balanced twisted pair.
2. Comply with the following requirements and for balanced twisted pair cable described in Section 260523 "Control-Voltage Electrical Power Cables."
3. Cable shall be plenum rated.
4. Cable shall comply with NFPA 70.
5. Cable shall have a unique color that is different from other cables used on Project.

2.16 CONTROL POWER WIRING AND RACEWAYS

A. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" electrical power conductors and cables.

B. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for electrical power raceways and boxes.

2.17 ACCESSORIES

A. Damper Blade Limit Switches:

1. Sense positive open and/or closed position of the damper blades.

2. NEMA 250, Type 13, oil-tight construction.
3. Arrange for the mounting application.
4. Additional waterproof enclosure when required by its environment.
5. Arrange to prevent "over-center" operation.

B. Manual Valves:

1. Needle Type:

a. PTFE packing.
b. Construct of brass for use with copper and polyethylene tubing and of stainless steel for use with stainless-steel tubing.
c. Aluminum T-bar handle.
d. Include tubing connections.

2. Ball Type:

a. Body: Bronze ASTM B62 or ASTM B61.
b. Ball: Type 316 stainless steel.
c. Stem: Type 316 stainless steel.
d. Seats: Reinforced PTFE.
e. Packing Ring: Reinforced PTFE.
f. Lever: Stainless steel with a vinyl grip.
g. 600 WOG.
h. Threaded end connections.

2.18 IDENTIFICATION

A. Valve Tags:

1. Brass tags and brass chains attached to valve.
2. Tags shall be at least 1.5 inches in diameter.
3. Include tag with unique valve identification indicating control influence such as flow, level, pressure, or temperature; followed by location of valve, and followed by three-digit sequential number.
4. Valves with Project-specific identification tags having unique identification numbers following requirements indicated and provided by original manufacturer do not require an additional tag.

B. Raceway and Boxes:

1. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

1. Verify compatibility with and suitability of substrates.

B. Examine roughing-in for products to verify actual locations of connections before installation.

1. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.
2. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

C. Examine walls, floors, roofs, and ceilings for suitable conditions where product will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Install products to satisfy more stringent of all requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Support products, tubing, piping wiring and raceways. Brace products to prevent lateral movement and sway or a break in attachment.

D. If codes and referenced standards are more stringent than requirements indicated, comply with requirements in codes and referenced standards.

E. Fabricate openings and install sleeves in ceilings, floors, roof, and walls required by installation of products. Before proceeding with drilling, punching, and cutting, check for concealed work to avoid damage. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

F. Firestop Penetrations Made in Fire-Rated Assemblies: Comply with requirements in Section 078413 "Penetration Firestopping."

G. Seal penetrations made in acoustically rated assemblies. Comply with requirements in Section 079200 "Joint Sealants."

H. Welding Requirements:

1. Restrict welding and burning to supports and bracing.
2. No equipment shall be cut or welded without approval. Welding or cutting will not be approved if there is risk of damage to adjacent Work.
3. Welding, where approved, shall be by inert-gas electric arc process and shall be performed by qualified welders according to applicable welding codes.
4. If requested on-site, show satisfactory evidence of welder certificates indicating ability to perform welding work intended.

I. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that damage surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening fasteners.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts and screws with graphite and oil before assembly.

J. If product locations are not indicated, install products in locations that are accessible and that will permit service and maintenance from floor, equipment platforms, or catwalks without removal of permanently installed furniture and equipment.

3.3 ROUTER INSTALLATION

A. Install routers if required for DDC system communication interface requirements indicated.

B. Test router to verify that communication interface functions properly.

3.4 CONTROLLER INSTALLATION

A. Install controllers in enclosures to comply with indicated requirements.

B. Connect controllers to field power supply and to UPS units where indicated.

C. Install controller with latest version of applicable software and configure to execute requirements indicated.

D. Test and adjust controllers to verify operation of connected I/O to achieve performance indicated requirements while executing sequences of operation.

E. Installation of Network Controllers:

1. Quantity and location of network controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
2. Install controllers in a protected location that is easily accessible by operators.
3. Top of controller shall be within 72 inches of finished floor.

F. Installation of Programmable Application Controllers:

1. Quantity and location of programmable application controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
2. Install controllers in a protected location that is easily accessible by operators.

G. Application-Specific Controllers:

1. Quantity and location of application-specific controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
2. For controllers not mounted directly on equipment being controlled, install controllers in a protected location that is easily accessible by operators.

3.5 ENCLOSURES INSTALLATION

A. Install the following items in enclosures, to comply with indicated requirements:

1. Gateways.
2. Routers.
3. Controllers.
4. Electrical power devices.

5. UPS units.
6. Relays.

B. Attach wall-mounted enclosures to wall using the following types of steel struts:

1. For NEMA 250, Type 1 Enclosures: Use painted steel strut and hardware.
2. For NEMA 250, Type 4 Enclosures and Enclosures Located Outdoors: Use stainless-steel strut and hardware.
3. Install plastic caps on exposed cut edges of strut.

C. Align top of adjacent enclosures.

D. Install floor-mounted enclosures located on concrete housekeeping pads. Attach enclosure legs using galvanized- or stainless-steel anchors.

3.6 ELECTRIC POWER CONNECTIONS

A. Connect electrical power to DDC system products requiring electrical power connections.

B. Design of electrical power to products not indicated with electric power is delegated to DDC system provider and installing trade. Work shall comply with NFPA 70 and other requirements indicated.

C. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers" for electrical power circuit breakers.

D. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for electrical power conductors and cables.

E. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for electrical power raceways and boxes.

3.7 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements in Section 260553 "Identification for Electrical Systems" for identification products and installation.

B. Install unique instrument identification on face of each instrument connected to a DDC controller.

C. Install unique identification on face of each control actuator connected to a DDC controller.

D. Where product is installed above accessible tile ceiling, also install matching identification on face of ceiling grid located directly below.

E. Where product is installed above an inaccessible ceiling, also install identification on face of access door directly below.

3.8 NETWORK NAMING AND NUMBERING

A. Coordinate with Owner and provide unique naming and addressing for networks and devices.

3.9 CONTROL WIRE, CABLE AND RACEWAYS INSTALLATION

A. Comply with NECA 1.

B. Wire and Cable Installation:

1. Comply with installation requirements in Section 260523 "Control-Voltage Electrical Power Cables."
2. Comply with installation requirements in Section 271313 "Communications Copper Backbone Cabling."
3. Comply with installation requirements in Section 271513 "Communications Copper Horizontal Cabling."

4. Provide strain relief.
5. Terminate wiring in a junction box.

    a. Clamp cable over jacket in junction box.
    b. Individual conductors in the stripped section of the cable shall be slack between the clamping point and terminal block.

6. Terminate field wiring and cable not directly connected to instruments and control devices having integral wiring terminals using terminal blocks.
7. Install signal transmission components according to IEEE C2, REA Form 511a, NFPA 70, and as indicated.
8. Use shielded cable to transmitters.
9. Use shielded cable to temperature sensors.
10. Perform continuity and meager testing on wire and cable after installation.

C. Conduit Installation:

1. Comply with Section "260533 "Raceways and Boxes for Electrical Systems" for control-voltage conductors.
2. Comply with Section 270528 "Pathways for Communications Systems" for balanced twisted pair cabling and optical fiber installation.

3.10 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Testing:

1. Perform preinstallation, in-progress, and final tests, supplemented by additional tests, as necessary.
2. Preinstallation Cable Verification: Verify integrity and serviceability for new cable lengths before installation. This assurance may be provided by using vendor verification documents, testing, or other methods. As a minimum, furnish evidence of verification for cable attenuation and bandwidth parameters.

3. In-Progress Testing: Perform standard tests for correct pair identification and termination during installation to ensure proper installation and cable placement. Perform tests in addition to those specified if there is any reason to question condition of material furnished and installed. Testing accomplished is to be documented by agency conducting tests. Submit test results for Project record.
4. Final Testing: Perform final test of installed system to demonstrate acceptability as installed. Testing shall be performed according to a test plan supplied by DDC system manufacturer. Defective Work or material shall be corrected and retested. As a minimum, final testing for cable system, including spare cable, shall verify conformance of attenuation, length, and bandwidth parameters with performance indicated.
5. Test Equipment: Use an optical fiber time domain reflectometer for testing of length and optical connectivity.
6. Test Results: Record test results and submit copy of test results for Project record.

3.11 DDC SYSTEM I/O CHECKOUT PROCEDURES

A. Check installed products before continuity tests, leak tests and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.

D. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material and support.

E. Control Damper Checkout:

1. Verify that control dampers are installed correctly for flow direction.
2. Verify that proper blade alignment, either parallel or opposed, has been provided.
3. Verify that damper frame attachment is properly secured and sealed.
4. Verify that damper actuator and linkage attachment is secure.
5. Verify that actuator wiring is complete, enclosed and connected to correct power source.
6. Verify that damper blade travel is unobstructed.

F. Control Valve Checkout:
1. Verify that control valves are installed correctly for flow direction.
2. Verify that valve body attachment is properly secured and sealed.
3. Verify that valve actuator and linkage attachment is secure.
4. Verify that actuator wiring is complete, enclosed and connected to correct power source.
5. Verify that valve ball, disc or plug travel is unobstructed.
6. After piping systems have been tested and put into service, but before insulating and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks. Replace the valve if leaks persist.

G. Instrument Checkout:

1. Verify that instrument is correctly installed for location, orientation, direction and operating clearances.
2. Verify that attachment is properly secured and sealed.
3. Verify that conduit connections are properly secured and sealed.
4. Verify that wiring is properly labeled with unique identification, correct type and size and is securely attached to proper terminals.
5. Inspect instrument tag against approved submittal.
6. For instruments with tubing connections, verify that tubing attachment is secure and isolation valves have been provided.

7. For flow instruments, verify that recommended upstream and downstream distances have been maintained.
8. For temperature instruments:

    a. Verify sensing element type and proper material.
    b. Verify length and insertion.

3.12 DDC SYSTEM I/O ADJUSTMENT, CALIBRATION AND TESTING:

A. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.

B. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.

C. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.

D. Equipment and procedures used for calibration shall comply with instrument manufacturer's written instructions.

E. Provide diagnostic and test equipment for calibration and adjustment.

F. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. An installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.

G. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.

H. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.

I. Comply with field testing requirements and procedures indicated by ASHRAE's Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

J. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.

K. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact making or breaking.

L. Control Dampers:

1. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.

2. Stroke control dampers with pilot positioners. Adjust damper and positioner following manufacturer's recommended procedure, so damper is 100 percent closed, 50 percent closed and 100 percent open at proper air pressure.
3. Check and document open and close cycle times for applications with a cycle time less than 30 seconds.
4. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

M. Control Valves:

1. Stroke and adjust control valves following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.
2. Stroke control valves with pilot positioners. Adjust valve and positioner following manufacturer's recommended procedure, so valve is 100 percent closed, 50 percent closed and 100 percent open at proper air pressures.
3. Check and document open and close cycle times for applications with a cycle time less than 30 seconds.
4. For control valves equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

N. Meters: Check sensors at zero, 50, and 100 percent of Project design values.

O. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

P. Switches: Calibrate switches to make or break contact at set points indicated.

Q. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistant source.

3.13 DDC SYSTEM CONTROLLER CHECKOUT

A. Verify power supply.

1. Verify voltage, phase and hertz.
2. Verify that protection from power surges is installed and functioning.
3. Verify that ground fault protection is installed.
4. If applicable, verify if connected to UPS unit.
5. If applicable, verify if connected to a backup power source.
6. If applicable, verify that power conditioning units, transient voltage suppression and high-frequency noise filter units are installed.

B. Verify that wire and cabling is properly secured to terminals and labeled with unique identification.

C. Verify that spare I/O capacity is provided.

3.14 DDC CONTROLLER I/O CONTROL LOOP TESTS

A. Testing:

1. Test every I/O point connected to DDC controller to verify that safety and operating control set points are as indicated and as required to operate controlled system safely and at optimum performance.
2. Test every I/O point throughout its full operating range.
3. Test every control loop to verify operation is stable and accurate.
4. Adjust control loop proportional, integral and derivative settings to achieve optimum performance while complying with performance requirements indicated. Document testing of each control loop's precision and stability via trend logs.
5. Test and adjust every control loop for proper operation according to sequence of operation.
6. Test software and hardware interlocks for proper operation. Correct deficiencies.
7. Operate each analog point at the following:

    a. Upper quarter of range.
    b. Lower quarter of range.
    c. At midpoint of range.

8. Exercise each binary point.
9. For every I/O point in DDC system, read and record each value at operator workstation, at DDC controller and at field instrument simultaneously. Value displayed at operator workstation, at DDC controller and at field instrument shall match.
10. Prepare and submit a report documenting results for each I/O point in DDC system and include in each I/O point a description of corrective measures and adjustments made to achieve desire results.

3.15 DDC SYSTEM VALIDATION TESTS

A. Perform validation tests before requesting final review of system. Before beginning testing, first submit Pretest Checklist and Test Plan to Owner.

B. After testing is complete, submit completed test checklist.

3.16 FINAL REVIEW

A. Submit written request to Owner when DDC system is ready for final review. Written request shall state the following:

1. DDC system has been thoroughly inspected for compliance with contract documents and found to be in full compliance.
2. DDC system has been calibrated, adjusted and tested and found to comply with requirements of operational stability, accuracy, speed and other performance requirements indicated.
3. DDC system monitoring and control of HVAC systems results in operation according to sequences of operation indicated.
4. DDC system is complete and ready for final review.

B. Review by Owner shall be made after receipt of written request. A field report shall be issued to document observations and deficiencies.

C. Take prompt action to remedy deficiencies indicated in field report and submit a second written request when all deficiencies have been corrected. Repeat process until no deficiencies are reported.

D. Should more than two reviews be required, DDC system manufacturer and Installer shall compensate entity performing review for total costs, labor and expenses, associated with third and subsequent reviews. Estimated cost of each review shall be submitted and approved by DDC system manufacturer and Installer before making the review.

E. Prepare and submit closeout submittals when no deficiencies are reported.

F. A part of DDC system final review shall include a demonstration to parties participating in final review.

1. Provide staff familiar with DDC system installed to demonstrate operation of DDC system during final review.
2. Provide testing equipment to demonstrate accuracy and other performance requirements of DDC system that is requested by reviewers during final review.

3.17 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.18 DEMONSTRATION

A. Engage a factory-authorized service representative with complete knowledge of Project-specific system installed to train Owner's maintenance personnel to adjust, operate, and maintain DDC system. Submit training plan to Owner for approval.

B. Extent of Training:

1. Base extent of training on scope and complexity of DDC system indicated and training requirements indicated. Provide extent of training required to satisfy requirements indicated even if more than minimum training requirements are indicated.
2. Inform Owner of anticipated training requirements if more than minimum training requirements are indicated.
3. Minimum Training Requirements:

    a. Provide not less than two days of training total.
    b. Plan in advance of training for five attendees.
    c. Headcount may vary depending on training content covered in session. Attendee access may be restricted to some training content for purposes of maintaining system security.

C. Training Schedule:

1. Schedule training to provide Owner with at least 15 business days of notice in advance of training.
2. Training shall occur within normal business hours at a mutually agreed on time. Unless otherwise agreed to, training shall occur Monday through Friday, except on U.S. Federal holidays.
3. Provide staggered training schedule as requested by Owner.

D. On-Site Training:

1. Owner will provide conditioned classroom or workspace with ample desks or tables, chairs, power and data connectivity for instructor and each attendee.
2. Instructor shall provide training materials, projector and other audiovisual equipment used in training.
3. Provide as much of training located on-site as deemed feasible and practical by Owner.
4. On-site training shall include regular walk-through tours, as required, to observe each unique product type installed with hands-on review of operation, calibration and service requirements.
5. Operator workstation provided with DDC system shall be used in training. If operator workstation is not indicated, provide a temporary workstation to convey training content.

END OF SECTION 230923

SECTION 230923.11 - CONTROL VALVES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes control valves and actuators for DDC systems.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Delegated-Design Submittal:

1. Schedule and design calculations for control valves and actuators, including the following:

a. Flow at project design and minimum flow conditions.
b. Pressure differential drop across valve at project design flow condition.
c. Maximum system pressure differential drop (pump close-off pressure) across valve at project minimum flow condition.
d. Design and minimum control valve coefficient with corresponding valve position.
e. Maximum close-off pressure.
f. Leakage flow at maximum system pressure differential.
g. Torque required at worst case condition for sizing actuator.
h. Actuator selection indicating torque provided.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASME Compliance: Fabricate and label products to comply with ASME Boiler and Pressure Vessel Code where required by authorities having jurisdiction.

C. Ground Fault: Products shall not fail due to ground fault condition when suitably grounded.

D. Determine control valve sizes and flow coefficients by ISA 75.01.01.

E. Control valve characteristics and rangeability shall comply with ISA 75.11.01.

F. Selection Criteria:

1. Control valves shall be suitable for operation at following conditions:

   a. Chilled Water: 100 psig at 200 deg. F.
   b. Heating Hot Water: 150 psig at 73 deg. F

2. Fail positions unless otherwise indicated:

   a. Chilled Water: Last position.
   b. Heating Hot Water: Last position.

3. Minimum Cv shall be calculated at 10percent of design flow, with a coincident pressure differential equal to the system design pump head.
4. In water systems, select modulating control valves at terminal equipment for a design Cv based on a pressure drop of no more than 5 psig across the entire assembly at design flow unless otherwise indicated.

2.2 BALL-STYLE CONTROL VALVES

A. Ball Valves with Two Ports and Characterized Disk:

1. Subject to compliance with the requirements, provide products by the following or approved equal.

   a. Belimo (B3 Series, Basis of Design)

2. Pressure Rating for NPS 1 and Smaller: Nominal 600 WOG.
3. Pressure Rating for NPS 1-1/2 through NPS 2: Nominal 400 WOG.
4. Close-off Pressure: 200 psig.
5. Process Temperature Range: Zero to 212 deg F.
6. Body and Tail Piece: Cast bronze ASTM B61, ASTM B62, ASTM B584, or forged brass with nickel plating.
7. End Connections: Threaded (NPT) ends.
8. Ball: 300 series stainless steel.
9. Stem and Stem Extension:

   a. Material to match ball.
   b. Blowout-proof design.
   c. Sleeve or other approved means to allow valve to be opened and closed without damaging the insulation or the vapor barrier seal.

10. Ball Seats: Reinforced PTFE.
11. Stem Seal: Reinforced PTFE packing ring with a threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if an equivalent cycle endurance can be demonstrated by testing.
12. Flow Characteristics for A-Port: Equal percentage.
13. Flow Characteristics for B-Port: Modified for constant common port flow.

B. Pressure-Independent Ball Valves NPS 2 and Smaller:

1. Subject to compliance with the requirements, provide products by the following or approved equal.

   a. Belimo (PICCV, Basis of Design)

2. Performance:

   a. Pressure Rating: 600 psig for NPS 1 and 400 psig for NPS 1-1/2 and NPS 2.
   b. Close-off pressure of 200 psig.
   c. Process Temperature Range: Between zero to 212 deg F.
   d. Rangeability: 100 to 1.

3. Integral Pressure Regulator: Located upstream of ball to regulate pressure, to maintain a constant pressure differential while operating within a pressure differential range of 5 to 50 psig.
4. Body: Forged brass, nickel plated, and with threaded ends.
5. Ball: Chrome-plated brass.
6. Stem and Stem Extension: Chrome-plated brass, blowout-proof design.
7. Stem sleeve or other approved means to allow valve to be opened and closed without damaging field-applied insulation and insulation vapor barrier seal.
8. Ball Seats: Reinforced PTFE.
9. Stem Seal: Reinforced PTFE packing ring stem seal with threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if equivalent cycle endurance can be achieved.
10. Flow Characteristic: Equal percentage.

2.3 ELECTRIC AND ELECTRONIC CONTROL VALVE ACTUATORS

A. Actuators for Hydronic Control Valves: Capable of closing valve against system pump shutoff head.

B. Position indicator and graduated scale on each actuator.

C. Type: Motor operated, with or without gears, electric and electronic.

D. Voltage: 24-V ac.

E. Deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.

F. Function properly within a range of 85 to 120 percent of nameplate voltage.

G. Construction:

1. For Actuators Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed steel enclosures.
2. For Actuators from 100 to 400 W: Gears ground steel, oil immersed, shaft hardened steel running in bronze, copper alloy or ball bearings. Operator and gear trains shall be totally enclosed in dustproof cast-iron, cast-steel or cast-aluminum housing.

3. For Actuators Larger Than 400 W: Totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.

H. Field Adjustment:

1. Spring Return Actuators: Easily switchable from fail open to fail closed in the field without replacement.
2. Gear Type Actuators: External manual adjustment mechanism to allow manual positioning when the actuator is not powered.

I. Two-Position Actuators: Single direction, spring return or reversing type.

J. Modulating Actuators:

1. Operation: Capable of stopping at all points across full range, and starting in either direction from any point in range.

K. Position Feedback:

1. Where indicated, equip modulating actuators with a position feedback through current or voltage signal for remote monitoring.
2. Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.

L. Fail-Safe:

1. Where indicated, provide actuator to fail to an end position.
2. Internal spring return mechanism to drive controlled device to an end position (open or close) on loss of power.
3. Batteries, capacitors, and other non-mechanical forms of fail-safe operation are acceptable only where uniquely indicated.

M. Integral Overload Protection:

1. Provide against overload throughout the entire operating range in both directions.
2. Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.

N. Valve Attachment:

1. Unless otherwise required for valve interface, provide an actuator designed to be directly coupled to valve shaft without the need for connecting linkages.
2. Attach actuator to valve drive shaft in a way that ensures maximum transfer of power and torque without slippage.
3. Bolt and set screw method of attachment is acceptable only if provided with at least two points of attachment.

O. Temperature and Humidity:

1. Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature range of minus 20 to plus 120 deg F.
2. Humidity: Suitable for humidity range encountered by application; minimum operating range shall be from 5 to 95 percent relative humidity, non-condensing.

P. Enclosure:

1. Suitable for ambient conditions encountered by application.
2. NEMA 250, Type 2 for indoor and protected applications.
3. NEMA 250, Type 4 or Type 4X for outdoor and unprotected applications.
4. Provide actuator enclosure with heater and control where required by application.

Q. Stroke Time:

1. Operate valve from fully closed to fully open within 15 seconds.
2. Operate valve from fully open to fully closed within 15 seconds.
3. Move valve to failed position within 5 seconds.
4. Select operating speed to be compatible with equipment and system operation.

R. Sound:

1. Spring Return: 62 dBA.
2. Non-Spring Return: 45 dBA.

PART 3 - EXECUTION

3.1 CONTROL VALVE APPLICATIONS

A. Control Valves:

1. Chilled Water System, Two-Way Applications Controlled by Flow: Pressure-independent ball valves.
2. Heating Hot Water System, Two-Way Applications Controlled by Pressure: Pressure-independent ball valves.
3. Heating Hot Water System, Three Way, Controlled by Temperature: Ball valves with two ports and characterized disk.

3.2 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy most stringent requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Properly support instruments, tubing, piping, wiring, and conduits to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment.

D. Provide ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

E. Firestop penetrations made in fire-rated assemblies and seal penetrations made in acoustically rated assemblies.

F. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that will cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

G. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

3.3 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.4 CONTROL VALVES

A. Install pipe reducers for valves smaller than line size. Position reducers as close to valve as possible but at distance to avoid interference and impact to performance. Install with manufacturer-recommended clearance.

B. Install flanges or unions to allow drop-in and -out valve installation.

C. Install drain valves in piping upstream and downstream of each control valve installed in a three-valve manifold and for each control valve larger than [NPS 2] [NPS 4] <Insert nominal pipe size>.

D. Install pressure temperature taps in piping upstream and downstream of each control valve.

E. Valve Orientation:

1. Where possible, install globe and ball valves installed in horizontal piping with stems upright and not more than 15 degrees off of vertical, not inverted.
2. Install valves in a position to allow full stem movement.
3. Where possible, install butterfly valves that are installed in horizontal piping with stems in horizontal position and with low point of disc opening with direction of flow.

F. Clearance:

1. Locate valves for easy access and provide separate support of valves that cannot be handled by service personnel without hoisting mechanism.
2. Install valves with at least 12 inches of clear space around valve and between valves and adjacent surfaces.

G. Threaded Valves:

1. Note internal length of threads in valve ends, and proximity of valve internal seat or wall, to determine how far pipe should be threaded into valve.
2. Align threads at point of assembly.
3. Apply thread compound to external pipe threads, except where dry seal threading is specified.
4. Assemble joint, wrench tight. Apply wrench on valve end as pipe is being threaded.

H. Flanged Valves:

1. Align flange surfaces parallel.
2. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly with a torque wrench.

I. Connect electrical devices and components to electrical grounding system. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

J. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

K. Install engraved phenolic nameplate with valve identification on valve.

3.5 CHECKOUT PROCEDURES

A. Control Valve Checkout:

1. Check installed products before continuity tests, leak tests, and calibration.
2. Check valves for proper location and accessibility.
3. Check valves for proper installation for direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
4. Verify that control valves are installed correctly for flow direction.
5. Verify that valve body attachment is properly secured and sealed.
6. Verify that valve actuator and linkage attachment are secure.
7. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
8. Verify that valve ball, disc, and plug travel are unobstructed.
9. After piping systems have been tested and put into service, but before insulating and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks. Replace the valve if leaks persist.

3.6 ADJUSTMENT, CALIBRATION, AND TESTING

A. Stroke and adjust control valves following manufacturer's recommended procedure, from 100 percent open to 100 percent closed back to 100 percent open.

B. Stroke control valves with pilot positioners. Adjust valve and positioner following manufacturer's recommended procedure, so valve is 100 percent closed, 50 percent closed, and 100 percent open at proper air pressures.

C. Check and document open and close cycle times for applications with a cycle time of less than 30 seconds.

D. For control valves equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

END OF SECTION 230923.11

SECTION 230923.12 - CONTROL DAMPERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes control dampers and actuators for DDC systems.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASME Compliance: Fabricate and label products to comply with ASME Boiler and Pressure Vessel Code where required by authorities having jurisdiction.

C. Ground Fault: Products shall not fail due to ground fault condition when suitably grounded.

D. Selection Criteria:

1. Fail positions unless otherwise indicated:

a. Supply Air: Open.
b. Return Air: Last position.
c. Outdoor Air: Last position.
d. Mixed Air: Last position.
e. Exhaust Air: Last position.

2. Select modulating dampers for a pressure drop of no more than 2percent of fan total static pressure unless otherwise indicated.

2.2 RECTANGULAR CONTROL DAMPERS

A. General Requirements:

1. Unless otherwise indicated, use parallel blade configuration for two-position control, equipment isolation service, and when mixing two airstreams. For other applications, use opposed blade configuration.
2. Factory assemble multiple damper sections to provide a single damper assembly of size required by the application.

B. Rectangular Dampers with Aluminum Airfoil Blades:

1. Performance:

a. Leakage: AMCA 511, Class 1A. Leakage shall not exceed 3 cfm/sq. ft. against 1-in. wg differential static pressure.
b. Pressure Drop: 0.05-in. wg at 1500 fpm across a 24-by-24-inch damper when tested according to AMCA 500-D, figure 5.3.
c. Velocity: Up to 6000 fpm.
d. Temperature: Minus 40 to plus 185 deg F.
e. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.
f. Damper shall have AMCA seal for both air leakage and air performance.

2. Construction:

a. Frame:

1) Material: ASTM B211, Alloy 6063 T5 extruded-aluminum profiles, 0.07 inch thick.
2) Hat-shaped channel with integral flange(s). Mating face shall be a minimum of 1 inch.
3) Width not less than 5 inches.

b. Blades:

1) Hollow, airfoil, extruded aluminum.
2) Parallel or opposed blade configuration as required by application.
3) Material: ASTM B211, Alloy 6063 T5 aluminum, 0.07 inch thick.
4) Width not to exceed 6 inches.
5) Length as required by close-off pressure, not to exceed 48 inches.

c. Seals:

1) Blades: Replaceable, mechanically attached extruded silicone, vinyl, or plastic composite.
2) Jambs: Stainless steel, compression type.

d. Axles: 0.5-inch-diameter stainless steel, mechanically attached to blades.
e. Bearings:

1) Molded synthetic or stainless-steel sleeve mounted in frame.
2) Where blade axles are installed in vertical position, provide thrust bearings.

f. Linkage:

1) Concealed in frame.
2) Constructed of aluminum and stainless steel.
3) Hardware: Stainless steel.

g. Transition:

1) For round and flat oval duct applications, provide damper assembly with integral transitions to mate to adjoining field connection.
2) Factory mount damper in a sleeve with a close transition to mate to field connection.
3) Damper size and sleeve shall be connection size plus 2 inches.
4) Sleeve length shall be not less than 12 inches for dampers without jackshafts and shall be not less than 16 inches for dampers with jackshafts.
5) Sleeve material shall match adjacent duct.

2.3 ROUND CONTROL DAMPERS

A. Round Dampers, Sleeve Type:

1. Performance:

a. Leakage: Leakage shall not exceed 0.15 cfm/in. of perimeter blade at 4-in. wg differential static pressure.
b. Pressure Drop: 0.02-in. wg at 1500 fpm across a 12-inch damper when tested according to AMCA 500-D, figure 5.3.
c. Velocity: Up to 4000 fpm.
d. Temperature: Minus 25 to plus 200 deg F.
e. Pressure Rating: 8-in. wg for sizes through 12 inches, 6-in. wg for larger sizes.

2. Construction:

a. Frame:

1) Material: Galvanized or stainless steel, 0.04 in thick. Use only stainless steel where duct material is stainless steel
2) Outward rolled stiffener beads positioned approximately 1 inch inboard of each end.
3) Sleeve-type connection for mating to adjacent ductwork.
4) Size Range: 4 to 24 inches.
5) Length not less than 7 inches.
6) Provide 2-inch sheet metal stand-off for mounting actuator.

b. Blade: Double-thickness circular flat blades sandwiched together and constructed of stainless steel.
c. Blade Seal: Polyethylene foam seal sandwiched between two sides of blades and fully encompassing blade edge.
d. Axle: 0.5-inch-diameter stainless steel, mechanically attached to blade.
e. Bearings: Stainless-steel sleeve pressed into frame.

B. Round Dampers, Flanged Type:

1. Performance:

a. Leakage: Leakage shall not exceed 0.15 cfm/in. of perimeter blade at 4-in. wg differential static pressure.
b. Pressure Drop: 0.03-in. wg at 1500 fpm across a 12-inch damper when tested according to AMCA 500-D, figure 5.3.
c. Velocity: Up to 4000 fpm.
d. Temperature: Minus 25 to plus 250 deg F.
e. Pressure Rating: 8-in. wg for sizes through 36 inches in diameter, 6-in. wg for larger sizes.

2. Construction:

a. Frame:

1) Size Range: 4 to 60 inches.
2) Material: Galvanized or stainless steel. Use only stainless steel where duct material is stainless steel

a) Sizes through 24 Inches in Diameter: 0.15 inch thick.
b) Sizes 26 through 48 Inches in Diameter: 0.25 inch thick.
c) Larger Sizes: 0.31 inch thick.

3) Flanges:

a) Outward rolled with bolt holes on each end of frame for mating to adjacent ductwork.
b) Face: Not less than 1.25 inch for damper sizes through 12 inches in diameter, 1.5 inch for damper sizes 14 through 24 inches in diameter, and 2 inches for larger sizes.

4) Length (Flange Face to Face): Not less than 8 inches.
5) Provide 3-inch sheet metal stand-off for mounting actuator.

b. Blade: Reinforced circular flat blade constructed of stainless steel.

1) Sizes through 24 Inches: 0.15 inch thick.
2) Sizes 26 through 48 Inches: 0.19 inch thick.
3) Larger Sizes: 0.25 inch thick.

c. Blade Stop: Full circumference, located in airstream, minimum 0.5 by 0.25 inch stainless steel bar.
d. Blade Seal: Neoprene, mechanically attached to blade and fully encompassing blade edge.
e. Axle: stainless steel, mechanically attached to blade.

1) Sizes through 14 Inches: 0.5 inch in diameter.
2) Sizes 16 through 42 Inches: 0.75 inch in diameter.
3) Larger Sizes: 1 inch in diameter.

f. Bearings: Stainless-steel sleeve pressed into frame.

2.4 GENERAL CONTROL-DAMPER ACTUATORS REQUIREMENTS

A. Actuators shall operate related damper(s) with sufficient reserve power to provide smooth modulating action or two-position action and proper speed of response at velocity and pressure conditions to which the damper is subjected.

B. Actuators shall produce sufficient power and torque to close off against the maximum system pressures encountered. Actuators shall be sized to close off against the fan shutoff pressure as a minimum requirement.

C. The total damper area operated by an actuator shall not exceed 80 percent of manufacturer's maximum area rating.

D. Provide one actuator for each damper assembly where possible. Multiple actuators required to drive a single damper assembly shall operate in unison.

E. Avoid the use of excessively oversized actuators which could overdrive and cause linkage failure when the damper blade has reached either its full open or closed position.

F. Use jackshafts and shaft couplings in lieu of blade-to-blade linkages when driving axially aligned damper sections.

G. Provide mounting hardware and linkages for connecting actuator to damper.

H. Select actuators to fail in desired position in the event of a power failure.

2.5 ELECTRIC AND ELECTRONIC ACTUATORS

A. Type: Motor operated, with or without gears, electric and electronic.

B. Voltage:

1. 24 V.
2. Actuator shall deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.
3. Actuator shall function properly within a range of 85 to 120 percent of nameplate voltage.

C. Construction:

1. Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed steel enclosures.
2. 100 up to 400 W: Gears ground steel, oil immersed, shaft-hardened steel running in bronze, copper alloy, or ball bearings. Operator and gear trains shall be totally enclosed in dustproof cast-iron, cast-steel, or cast-aluminum housing.
3. Greater Than 400 W: Totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.

D. Field Adjustment:

1. Spring return actuators shall be easily switchable from fail open to fail closed in the field without replacement.
2. Provide gear-type actuators with an external manual adjustment mechanism to allow manual positioning of the damper when the actuator is not powered.

E. Two-Position Actuators: Single direction, spring return or reversing type.

F. Modulating Actuators:

1. Capable of stopping at all points across full range, and starting in either direction from any point in range.

G. Position Feedback:

1. Where indicated, equip modulating actuators with a position feedback through current or voltage signal for remote monitoring.
2. Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.

H. Fail-Safe:

1. Where indicated, provide actuator to fail to an end position.
2. Internal spring return mechanism to drive controlled device to an end position (open or close) on loss of power.
3. Batteries, capacitors, and other non-mechanical forms of fail-safe operation are acceptable only where uniquely indicated.

I. Integral Overload Protection:

1. Provide against overload throughout the entire operating range in both directions.
2. Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.

J. Damper Attachment:

1. Unless otherwise required for damper interface, provide actuator designed to be directly coupled to damper shaft without need for connecting linkages.
2. Attach actuator to damper drive shaft in a way that ensures maximum transfer of power and torque without slippage.
3. Bolt and set screw method of attachment is acceptable only if provided with at least two points of attachment.

K. Temperature and Humidity:

1. Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature range of minus 20 to plus 120 deg F.
2. Humidity: Suitable for humidity range encountered by application; minimum operating range shall be from 5 to 95 percent relative humidity, non-condensing.

L. Enclosure:

1. Suitable for ambient conditions encountered by application.
2. NEMA 250, Type 2 for indoor and protected applications.
3. NEMA 250, Type 4 or Type 4X for outdoor and unprotected applications.
4. Provide actuator enclosure with a heater and controller where required by application.

M. Stroke Time:

1. Operate damper from fully closed to fully open within 15 seconds.

2. Operate damper from fully open to fully closed within 15 seconds.
3. Move damper to failed position within 5 seconds.
4. Select operating speed to be compatible with equipment and system operation.
5. Actuators operating in smoke control systems comply with governing code and NFPA requirements.

N. Sound:

1. Spring Return: 62 dBA.
2. Non-Spring Return: 45 dBA.

PART 3 - EXECUTION

3.1 CONTROL-DAMPER APPLICATIONS

A. Control Dampers:

B. Select from damper types indicated in "Control Dampers" Article to achieve performance requirements and characteristics indicated while subjected to full range of system operation encountered.

3.2 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy most stringent requirements indicated.

B. Properly support dampers and actuators, tubing, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment.

C. Provide ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

D. Seal penetrations made in fire-rated and acoustically rated assemblies.

E. Fastening Hardware:

1. Stillson wrenches, pliers, or other tools that will cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

F. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

G. Corrosive Environments:

1. Use products that are suitable for environment to which they will be subjected.

2. Use Type 316 stainless-steel tubing and fittings when in contact with a corrosive environment.
3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
4. Where actuators are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.3 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.4 CONTROL DAMPERS

A. Install smooth transitions, not exceeding 15 degrees, to dampers smaller than adjacent duct. Install transitions as close to damper as possible but at distance to avoid interference and impact to performance. Consult manufacturer for recommended clearance.

B. Clearance:

1. Locate dampers for easy access and provide separate support of dampers that cannot be handled by service personnel without hoisting mechanism.
2. Install dampers with at least 24 inches of clear space on sides of dampers requiring service access.

C. Service Access:

1. Dampers and actuators shall be accessible for visual inspection and service.
2. Install access door(s) in duct or equipment located upstream of damper to allow service personnel to hand clean any portion of damper, linkage, and actuator. Comply with requirements in Section 233300 "Air Duct Accessories."

D. Install dampers straight and true, level in all planes, and square in all dimensions. Install supplementary structural steel reinforcement for large multiple-section dampers if factory support alone cannot handle loading.

E. Attach actuator(s) to damper drive shaft.

F. For duct-mounted and equipment-mounted dampers installed outside of equipment, install a visible and accessible indication of damper position from outside.

G. Connect electrical devices and components to electrical grounding system. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

H. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

I. Install engraved phenolic nameplate with damper identification on damper.

3.5 CHECKOUT PROCEDURES

A. Control-Damper Checkout:

1. Check installed products before continuity tests, leak tests, and calibration.
2. Check dampers for proper location and accessibility.
3. Verify that control dampers are installed correctly for flow direction.
4. Verify that proper blade alignment, either parallel or opposed, has been provided.
5. Verify that damper frame attachment is properly secured and sealed.
6. Verify that damper actuator and linkage attachment are secure.
7. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
8. Verify that damper blade travel is unobstructed.

3.6 ADJUSTMENT, CALIBRATION, AND TESTING:

A. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed back to 100 percent open.

B. Check and document open and close cycle times for applications with a cycle time of less than 30 seconds.

C. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

END OF SECTION 230923.12

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 230923.14 - FLOW INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Airflow sensors.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each product requiring a certificate.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Select and size products to achieve specified performance requirements.

B. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 AIRFLOW SENSORS:

A. Performance Requirements:

1. Adjustable for changes in system operational parameters.
2. Airflow Sensor and Transmitter Range: Extended range of no less than 20 percent above Project design flow and 20 percent below minimum Project flow to signal abnormal flow conditions.

3. Manufacturer shall certify that each flow instrument indicated complies with specified performance requirements and characteristics.

    a. Product certificates are required.

B. Thermal Airflow Station:

1. Source Limitations: Obtain airflow and temperature measuring sensors and transmitters from single manufacturer.
2. Description: Airflow station shall consist of one or more sensor probes mounted in a casing, and a remotely mounted microprocessor-based transmitter.
3. Performance:

    a. Capable of independently processing up to 16 independently wired sensor assemblies.
    b. Airflow rate of each sensor assembly shall be equally weighted and averaged by transmitter prior to output.
    c. Temperature of each sensor assembly shall be velocity weighted and averaged by transmitter prior to output.
    d. Listed and labeled by an NRTL as successfully tested as an assembly according to UL 873, "Temperature-Indicating and Regulating Equipment."
    e. Components shall be interconnected by exposed NRTL-listed plenum-rated cable or non-listed cable placed in conduit.
    f. Each flow station shall be factory calibrated at a minimum of 16 airflow rates and three temperatures to standards that are traceable to NIST.
    g. Airflow Accuracy: Within 2 percent of reading over the entire operating airflow range.

        1) Devices whose accuracy is combined accuracy of transmitter and sensor probes must demonstrate that total accuracy meets the performance requirements throughout the measurement range.

    h. Temperature Accuracy: Within 0.2 deg F over entire operating range of minus 20 to plus 140 deg F.
    i. Sensor Ambient Operating Temperature Range: Minus 20 to plus 160 deg F.
    j. Transmitter Ambient Operating Temperature Range: Minus 20 to plus 120 deg F.
    k. Sensor and Transmitter Ambient Operating Humidity Range: Zero to 99 percent, non-condensing.
    l. Instrument shall compensate for changes in air temperature and density throughout calibrated velocity range for seasonal extremes at Project location.
    m. Pressure Drop: 0.05-inch wg at 2000 fpm across a 24-by-24-inch area.
    n. Instruments mounted in throat or face of fan inlet cone shall not negatively influence fan performance by reducing flow more than 1 percent of Project design flow or negatively impact fan-generated sound. Losses in performance shall be documented with submittal data, and adjustments to compensate for performance impact shall be made to fan in order to deliver Project design airflow indicated.

4. Sensor Assemblies:

    a. Each sensor probe shall contain two individually wired, hermetically sealed bead-in-glass thermistors.
    b. Mount thermistors in sensor using a marine-grade, waterproof epoxy.
    c. Thermistor leads shall be protected and not exposed to the environment.
    d. Each sensor assembly shall independently determine airflow rate and temperature at each measurement point.

e. Each sensor probe shall have an integral cable for connection to remotely mounted transmitter.
f. Sensor Probe Material: Gold anodized, extruded 6063 aluminum tube or Type 304 stainless steel.
g. Probe Assembly Mounting Brackets Material: Type 304 stainless steel.

5. Transmitter:

a. Integral digital display capable of simultaneously displaying total airflow and average temperature, individual airflow, and temperature readings of each independent sensor assembly.
b. Capable of field configuration and diagnostics using an onboard push-button interface and digital display.

1) Include an integral power switch to operate on 24-V ac (isolation not required) and include the following:

a) Integral protection from transients and power surges.
b) Circuitry to ensure reset after power disruption, transients, and brownouts.
c) Integral transformer to convert field power source to operating voltage required by instrument.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy more stringent of all requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Properly support instruments, tubing, piping wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment.

D. Install ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

E. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

F. Corrosive Environments:

1. Use products that are suitable for environment to which they will be subjected.
2. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings with a corrosive-resistant coating that is suitable for environment.
3. Where instruments are located in a corrosive environment and are not corrosive resistant from the manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.2 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.3 INSTRUMENTS, GENERAL INSTALLATION REQUIREMENTS

A. Mounting Height:

1. Mount switches and transmitters, located in mechanical equipment rooms and other similar space not subject to code, state, and federal accessibility requirements, within a range of 42 to 72 inches above the adjacent floor, grade, or service catwalk or platform.

a. Make every effort to mount at 60 inches.

B. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

3.4 FLOW INSTRUMENTS INSTALLATION

A. Airflow Sensors:

1. Install sensors in straight sections of duct with manufacturer-recommended straight duct upstream and downstream of sensor.
2. Installed sensors shall be accessible for visual inspection and service. Install access door(s) in duct or equipment located upstream of sensor, to allow service personnel to hand clean sensors.

B. Transmitters:

1. Install airflow transmitters serving an air system in a single location adjacent to or within system control panel.

3.5 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification.

3.6 CHECKOUT PROCEDURES

A. Description:

1. Check out installed products before continuity tests, leak tests, and calibration.
2. Check instruments for proper location and accessibility.
3. Check instruments for proper installation with respect to direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
4. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.

B. Flow Instrument Checkout:

1. Verify that sensors are installed correctly with respect to flow direction.
2. Verify that sensor attachment is properly secured and sealed.
3. Verify that processing tubing attachment is secure and isolation valves have been provided.
4. Inspect instrument tag against approved submittal.
5. Verify that recommended upstream and downstream distances have been maintained.

3.7 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

B. Coordinate video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.

C. Record videos on DVD disks.

D. Owner shall have right to make additional copies of video for internal use without paying royalties.

END OF SECTION 230923.14

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 230923.19 - MOISTURE INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes moisture switches, sensors, and transmitters.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 MOISTURE SENSORS AND TRANSMITTERS

A. Sensor and Transmitter without Display:

1. Performance:

a. Relative Humidity Range: Zero to 100 percent.
b. Accuracy: Within 2 percent.
c. Operating Temperatures: Minus 30 to 130 deg F.
d. Hysteresis: Within 1 percent.

2. Construction:

a. Duct-type sensor for duct-mounted applications. Integral-type sensor for room or space applications.
b. Sensor Body: 300 series stainless steel, 6 inches long for duct-mounted applications.
c. For outdoor and duct applications, install circuitry in a NEMA 250, Type 4 or 4X enclosure.

3. Output Signal:

a. Two-wire, 4- to 20-mA output signal with a drive capacity of at least 600 ohms at 24-V dc.
b. Non-interacting zero and span adjustments.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Properly support instruments, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment.

C. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

D. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

3.2 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.3 MOISTURE INSTRUMENTS INSTALLATION

A. Mounting Location: Rough-in instrument-mounting locations before setting instruments and routing, cable, wiring, tubing, and conduit to final location.

B. Mounting Height:

1. Mount instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.
2. Mount switches and transmitters located in mechanical equipment rooms and other similar space not subject to code, state, and Federal accessibility requirements within a range of 42 to 72 inches above the adjacent floor, grade, or service catwalk or platform.

a. Make every effort to mount at 60 inches.

3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.5 CHECKOUT PROCEDURES

A. Check installed products before continuity tests and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that impact performance.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

B. Coordinate video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.

C. Record videos on an electronic high definition video in MP4 or H264 format.

D. Owner shall have right to make additional copies of video for internal use without paying royalties.

END OF SECTION 230923.19

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 230923.23 - PRESSURE INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Air-pressure sensors.
2. Air-pressure switches.
3. Air-pressure transmitters.
4. Liquid-pressure switches.
5. Liquid-pressure transmitters.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 AIR-PRESSURE SENSORS

A. Duct Insertion Static Pressure Sensor:

1. Insertion length shall be at 4 inches.
2. Sensor with four radial holes of 0.04-inch diameter.
3. Brass or stainless-steel construction.
4. Sensor with threaded end support, sealing washers and nuts.
5. Connection: NPS 1/4 compression fitting.
6. Suitable for flat oval, rectangular, and round duct configurations.

2.2 AIR-PRESSURE SWITCHES

A. Air-Pressure Differential Switch:

1. Diaphragm operated to actuate an SPDT snap switch.

   a. Fan safety shutdown applications: Switch with manual reset.

2. Electrical Connections: Three-screw configuration, including one screw for common operation and two screws for field-selectable normally open or closed operation.
3. Enclosure Conduit Connection: Knock out or threaded connection.
4. User Interface: Screw-type set-point adjustment located inside removable enclosure cover.
5. High and Low Process Connections: Threaded, NPS 1/8.
6. Enclosure:

   a. Dry Indoor Installations: NEMA 250, Type 1.
   b. Outdoor and Wet Indoor Installations: NEMA 250, Type 4.
   c. Hazardous Environments: Explosion proof.

7. Operating Data:

   a. Electrical Rating: 15 A at 120- to 480-V ac.
   b. Pressure Limits:

      1) Continuous: 45 inches wg.
      2) Surge: 10 psig.

   c. Temperature Limits: Minus 30 to 180 deg F.
   d. Operating Range: Approximately 2 times set point.
   e. Repeatability: Within 3 percent.
   f. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 AIR-PRESSURE TRANSMITTERS

A. Air-Pressure Differential Transmitter:

1. Performance:

   a. Range: Approximately 2 times set point.
   b. Accuracy: Within 0.25 percent of the span at reference temperature of 70 deg F.
   c. Hysteresis: Within 0.02 percent of the span.
   d. Repeatability: Within 0.05 percent of the calibrated span.
   e. Stability: Within 0.25 percent of span per year.
   f. Overpressure: 15 psig.
   g. Temperature Limits: Minus 20 to 160 deg F.
   h. Compensate Temperature Limits: 35 to 135 deg F.
   i. Thermal Effects: 0.015 percent of full scale per degree F.
   j. Warm-up Time: Within 5 seconds.
   k. Response Time: 5 ms.
   l. Shock and vibration shall not harm the transmitter.

2. Operator Interface:

    a. Zero and span adjustments within 10 percent of full span.
    b. Potentiometer adjustments located on face of transmitter.

3. Construction:

    a. Type 300 stainless-steel enclosure.
    b. Swivel fittings for connection to copper tubing or barbed fittings for connection to polyethylene tubing. Fittings on front of instrument enclosure.
    c. Screw terminal block for wire connections.
    d. Vertical plane mounting.
    e. NEMA 250, Type 2.
    f. Mounting Bracket: Appropriate for installation.
    g. Reverse wiring protected.
    h. Calibrate to NIST-traceable standards and provide each transmitter with a certificate of calibration.

2.4 LIQUID-PRESSURE SWITCHES

A. Liquid Gage Pressure Switch, Diaphragm Operated, Low Pressure:

1. Description:

    a. Diaphragm operated to actuate an SPDT snap switch.
    b. Electrical Connections: Screw terminal.
    c. Enclosure Conduit Connection: Knock out or threaded connection.
    d. User Interface: External screw with visual set-point adjustment.
    e. Process Connection: Threaded, NPS 1/4.
    f. Enclosure:

        1) Dry Indoor Installations: NEMA 250, Type 1.
        2) Outdoor and Wet Indoor Installations: NEMA 250, Type 4.
        3) Hazardous Environments: Explosion proof.

2. Operating Data:

    a. Electrical Rating: 15 A at 120-V ac.
    b. Pressure Limits:

        1) Range 1 to 30 psig: 60 psig.
        2) Range 10 to 125 psig: 160 psig.

    c. Temperature Limits: Minus 30 to 150 deg F.
    d. Operating Range: 1 to 30 psig.
    e. Deadband: Fixed.

3. Pressure Chamber Material: Stainless steel.
4. Diaphragm Material: Nylon or PTFE.

B. Liquid-Pressure Differential Switch with Set-Point Indicator:

1. Description:

a. Brass or Type 316 stainless steel double opposing bellows operate to actuate a SPDT snap switch.
b. Electrical Connections: Screw terminal.
c. Enclosure Conduit Connection: Knock out or threaded connection.
d. User Interface: Thumbscrew set-point adjustment with enclosed set-point indicator and scale.
e. High and Low Process Connections: Threaded, NPS 1/8.
f. Enclosure:

1) Dry Indoor Installations: NEMA 250, Type 1.
2) Outdoor and Wet Indoor Installations: NEMA 250, Type 4.
3) Hazardous Environments: Explosion proof.

g. Operating Data:

1) Electrical Rating: 15 A at 120- to 240-V ac.
2) Pressure Limits: At least 5 times full-scale range, but not less than system design pressure rating.
3) Temperature Limits: Minus 10 to 180 deg F.
4) Operating Range: Approximately 2 times set point.
5) Deadband: Adjustable.

2.5 LIQUID-PRESSURE TRANSMITTERS

A. Liquid-Pressure Differential Transmitter:

1. Performance:

a. Range: Approximately 2 times set point.
b. Span: Adjustable plus or minus one milliamp, noninteractive.
c. Accuracy: Within 0.25 percent of full scale.
d. Pressure: Maximum operating pressure 2.5 times range.
e. Temperature Limits: Zero to 175 deg F.
f. Compensate Temperature Limits: 30 to 150 deg F.
g. Thermal Effects: 0.02 percent of full scale per degree F.
h. Response Time: 30 to 50 ms.
i. Shock and vibration shall not harm the transmitter.

2. Analog Output Current Signal:

a. Two-wire, 4- to 20-mA dc current source.
b. Signal capable of operating into 1000-ohm load.

3. Operator Interface:

a. Zero and span adjustments located behind cover.
b. Bleed screws on side of body, two screws on low-pressure side, and one screw on high-pressure side, for air in line and pressure cavity.

4. Construction:

   a. Aluminum and stainless-steel enclosure with removable cover.
   b. Wetted parts of transmitter constructed of 17-4 PH or 300 Series stainless steel.
   c. Threaded, NPS 1/4 process connections on side of instrument enclosure.
   d. Knock out for 1/2-inch nominal conduit connection on side of instrument enclosure.
   e. Screw terminal block for wire connections.
   f. NEMA 250, Type 4X.
   g. Mounting Bracket: Appropriate for installation.

5. Three-valve manifold. Construct manifold of brass, bronze, or stainless steel. Manifold shall have threaded, NPS 1/4 process connections.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Properly support instruments, tubing, piping wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement, sway, or a break in attachment

C. Provide ceiling, floor, roof, wall openings, and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

D. Fastening Hardware:

   1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
   2. Tighten bolts and nuts firmly and uniformly. Do not to overstress threads by using excessive force or oversized wrenches.
   3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

E. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

3.2 ELECTRICAL POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.3 PRESSURE INSTRUMENT INSTALLATION

A. Mounting Location:

1. Rough-in: Outline instrument-mounting locations before setting instruments and routing, cable, wiring, tubing, and conduit to final location.
2. Install switches and transmitters for air and liquid pressure associated with individual air-handling units and associated connected ductwork and piping near air-handlings units co-located in air-handling unit system control panel, to provide service personnel a single and convenient location for inspection and service.
3. Install liquid and steam pressure switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
4. Install air-pressure switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
5. Mount switches and transmitters not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.
6. Install instruments (except pressure gages) in steam, liquid, and liquid-sealed piped services below their process connection point. Slope tubing down to instrument with a slope of 2percent.
7. Install instruments in dry gas and noncondensable vapor piped services above their process connection point. Slope process connection lines up to instrument with a minimum slope of 2percent.

B. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

C. Duct Pressure Sensors:

1. Install sensors using manufacturer's recommended upstream and downstream distances.
2. Install mounting hardware and gaskets to make sensor installation airtight.
3. Route tubing from the sensor to transmitter.
4. Use compression fittings at terminations.
5. Install sensor in accordance with manufacturer's instructions.
6. Support sensor to withstand maximum air velocity, turbulence, and vibration encountered to prevent instrument failure.

D. Air-Pressure Differential Switches:

1. Install air-pressure sensor in system for each switch connection. Install sensor in an accessible location for inspection and replacement.
2. A single sensor may be used to share a common signal to multiple pressure instruments.
3. Install access door in duct and equipment to access sensors that cannot be inspected and replaced from outside.
4. Route NPS 3/8 tubing from sensor to switch connection.
5. Do not mount switches on rotating equipment.
6. Install switches in a location free from vibration, heat, moisture, or adverse effects, which could damage the switch and hinder accurate operation.
7. Install switches in an easily accessible location serviceable from floor.

E. Liquid-Pressure Differential Switches:

1. Where process connections are located in mechanical equipment room, install switch in convenient and accessible location near system control panel.

2. Where process connections are installed outside mechanical rooms, route processing tubing to mechanical room housing system control panel and locate switch near system control panel.
3. Where multiple switches serving same system are installed in same room, install switches by system to provide service personnel a single and convenient location for inspection and service.
4. System process tubing connection shall be full size of switch connection, but not less than NPS 3/4. Install bushing if required to mate switch to system connection.
5. Connect process tubing from point of system connection and extend to switch.
6. Install isolation valves in process tubing as close to system connection as practical.
7. Install dirt leg and drain valve at each switch connection.
8. Do not mount switches on rotating equipment.
9. Install switches in a location free from vibration, heat, moisture, or adverse effects, which could damage the switch and hinder accurate operation.
10. Install switches in an easily accessible location serviceable from floor.

F. Liquid-Pressure Transmitters:

1. Where process connections are installed in mechanical equipment room, install transmitter in convenient and accessible location near system control panel.
2. Where process connections are installed outside mechanical rooms, route processing tubing to mechanical room housing system control panel and locate transmitter near system control panel.
3. Where multiple transmitters serving same system are installed in same room, install transmitters by system to provide service personnel a single and convenient location for inspection and service.
4. System process tubing connection shall be full size of switch connection, but not less than NPS 3/4. Install bushing if required to mate switch to system connection.
5. Connect process tubing from point of system connection and extend to transmitter.
6. Install isolation valves in process tubing as close to system connection as practical.
7. Install dirt leg and drain valve at each transmitter connection.
8. Do not mount transmitters on equipment.
9. Install in a location free from vibration, heat, moisture, or adverse effects, which could damage and hinder accurate operation.

3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.5 CHECKOUT PROCEDURES

A. Check out installed products before continuity tests, leak tests, and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation with respect to direction of flow, elevation, orientation, insertion depth, or other applicable considerations that impact performance.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

B. Coordinate pressure instrument demonstration video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.

C. Record videos on an electronic high definition video file in MP$ or H264 format.

D. Owner shall have right to make additional copies of video for internal use without paying royalties.

END OF SECTION 230923.23

SECTION 230923.27 - TEMPERATURE INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Air temperature sensors.
2. Air temperature switches.
3. Liquid and steam temperature sensors.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Environmental Conditions:

1. Instruments shall operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.

a. If instrument alone cannot meet requirement, install instrument in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated and cooled, filtered, and ventilated as required by instrument and application.

2. Instruments and accessories shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Instruments not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Instrument's installed location shall dictate following NEMA 250 enclosure requirements:

a. Indoors, Heated and Air Conditioned: Type 1.

b. Mechanical Equipment Rooms:

1) Air-Moving Equipment Rooms: Type 1.

c. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: Type 2.
d. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: Type 4.

2.2 AIR TEMPERATURE SENSORS

A. Platinum RTDs: Common Requirements:

1. 100 or 1000 ohms at zero deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.
2. Two-wire, PTFE-insulated, 22-gage stranded copper leads.
3. Performance Characteristics:

a. Range: Minus 50 to 275 deg F.
b. Interchangeable Accuracy: At 32 deg F within 0.5 deg F.
c. Repeatability: Within 0.5 deg F.
d. Self-Heating: Negligible.

4. Transmitter Requirements:

a. Transmitter required for each 100-ohm RTD.
b. Transmitter optional for 1000-ohm RTD, contingent on compliance with end-to-end control accuracy.

B. Platinum RTD, Single-Point Air Temperature Duct Sensors:

1. 1000 ohms.
2. Temperature Range: Minus 50 to 275 deg F
3. Probe: Single-point sensor with a stainless-steel sheath.
4. Length: As required by application to achieve tip at midpoint of air tunnel, up to 18 inches.
5. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
6. Gasket for attachment to duct or equipment to seal penetration airtight.
7. Conduit Connection: 1/2-inch

C. Platinum RTD, Air Temperature Averaging Sensors:

1. 1000 ohms.
2. Temperature Range: Minus 50 to 275 deg F
3. Multiple sensors to provide average temperature across entire length of sensor.
4. Rigid probe of aluminum, brass, copper, or stainless-steel sheath.
5. Flexible probe of aluminum, brass, copper, or stainless-steel sheath and formable to a 4-inch radius.
6. Length: As required by application to cover entire cross section of air tunnel.
7. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
8. Gasket for attachment to duct or equipment to seal penetration airtight.
9. Conduit Connection: 1/2-inch

D. Platinum RTD Outdoor Air Temperature Sensors:

1. 1000 ohms.
2. Temperature Range: Minus 50 to 275 deg F
3. Probe: Single-point sensor with a stainless-steel sheath.
4. Solar Shield: Stainless steel.
5. Enclosure: NEMA 250, Type 4 or 4X junction box or combination conduit and outlet box with removable cover and gasket.
6. Conduit Connection: 1/2-inch trade size.

2.3 AIR TEMPERATURE SWITCHES

A. Thermostat and Switch for Low Temperature Control in Duct Applications:

1. Description:

a. Two-position control.
b. Field-adjustable set point.
c. Manual reset.
d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2. Performance:

a. Operating Temperature Range: 15 to 55 deg F.
b. Temperature Differential: 5 deg F, non-adjustable and additive.
c. Enclosure Ambient Temperature: Minus 20 to 140 deg F.
d. Sensing Element Maximum Temperature: 250 deg F.
e. Voltage: 120-V ac.
f. Current: 16 FLA.
g. Switch Type: Two SPDT snap switches operate on coldest 12-inchsection along element length.

3. Construction:

a. Vapor-Filled Sensing Element: Nominal 20 feet long.
b. Dual Temperature Scale: Fahrenheit and Celsius visible on face.
c. Set-Point Adjustment: Screw.
d. Enclosure: Painted metal, NEMA 250, Type 1.
e. Electrical Connections: Screw terminals.
f. Conduit Connection: 1/2-inch trade size.

2.4 LIQUID AND STEAM TEMPERATURE SENSORS, COMMERCIAL GRADE

A. RTD:

1. Description:

a. Platinum with a value of 1000 ohms at zero deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.
b. Encase RTD in a stainless-steel sheath with a 0.25-inch OD.

c. Sensor Length: 4, 6, or 8 inches as required by application.
d. Process Connection: Threaded, NPS 1/2
e. Two-stranded copper lead wires.
f. Powder-coated steel enclosure, NEMA 250, Type 4.
g. Conduit Connection: 1/2-inch
h. Performance Characteristics:

1) Range: Minus 40 to 210 deg F.
2) Interchangeable Accuracy: Within 0.54 deg F at 32 deg F.

B. Thermowells:

1. Stem: Straight shank formed from solid bar stock.
2. Material: Stainless steel.
3. Process Connection: Threaded, NPS 3/4.
4. Sensor Connection: Threaded, NPS 1/2.
5. Bore: Sized to accommodate sensor with tight tolerance between sensor and well.
6. Furnish thermowells installed in insulated pipes and equipment with an extended neck.
7. Length: 4, 6, or 8 inches as required by application.
8. Thermowells furnished with heat-transfer compound to eliminate air gap between wall of sensor and thermowell and to reduce time constant.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Properly support instruments, tubing, piping, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment.

C. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

D. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

3.2 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.3 TEMPERATURE INSTRUMENT INSTALLATIONS

A. Mounting Location:

1. Roughing In:

a. Outline instrument mounting locations before setting instruments and routing cable, wiring, tubing, and conduit to final location.
b. Provide independent inspection to confirm that proposed mounting locations comply with requirements indicated and approved submittals.

1) Indicate dimensioned locations with mounting height for all surface-mounted products on Shop Drawings.
2) Do not begin installation without submittal approval of mounting location.

c. Complete installation rough-in only after confirmation by independent inspection is complete and approval of location is documented for review by Owner and Architect on request.

2. Install switches and transmitters for air and liquid temperature associated with individual air-handling units and associated connected ductwork and piping near air-handling units co-located in air-handling unit system control panel to provide service personnel a single and convenient location for inspection and service.
3. Install liquid and steam temperature switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
4. Install air temperature switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
5. Mount switches and transmitters on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer's mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.

B. Special Mounting Requirements:

1. Temperature instruments having performance impacted by temperature of mounting substrate shall be isolated with an insulating barrier located between instrument and substrate to eliminate effect. Where instruments requiring insulation are located in finished space, conceal insulating barrier in a cover matching the instrument cover.

C. Mounting Height:

1. Mount temperature instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.

2. Mount switches and transmitters located in mechanical equipment rooms and other similar space not subject to code or state and Federal accessibility requirements within a range of 42 to 72 inches above the adjacent floor, grade, or service catwalk or platform.

    a. Make every effort to mount at 60 inches.

D. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

E. Outdoor Air Temperature Sensor Installation:

1. Mount sensor in a discrete location facing north.
2. Protect installed sensor from solar radiation and other influences that could impact performance.
3. If required to have a transmitter, mount transmitter remote from sensor in an accessible and serviceable location indoors.

F. Single-Point Duct Temperature Sensor Installation:

1. Install single-point-type, duct-mounted, supply- and return-air temperature sensors. Install sensors in ducts with sensitive portion of the element installed in center of duct cross section and located to sense near average temperature. Do not exceed 24 inches in sensor length.
2. Install return-air sensor in location that senses return-air temperature without influence from outdoor or mixed air.
3. Rigidly support sensor to duct and seal penetration airtight.
4. If required to have transmitter, mount transmitter remote from sensor at accessible and serviceable location.

G. Averaging Duct Temperature Sensor Installation:

1. Install averaging-type air temperature sensor for temperature sensors located within air-handling units, similar equipment, and large ducts with air tunnel cross-sectional area of 20 sq. ft. and larger or otherwise indicated on drawings.
2. Install sensor length to maintain coverage over entire cross-sectional area. Install multiple sensors where required to maintain the minimum coverage.
3. Fasten and support sensor with manufacturer-furnished clips to keep sensor taut throughout entire length.
4. If required to have transmitter, mount transmitter in an accessible and serviceable location.

H. Low-Limit Air Temperature Switch Installation:

1. Install multiple low-limit switches to maintain coverage over entire cross-sectional area of air tunnel.
2. Fasten and support sensing element with manufacturer-furnished clips to keep element taut throughout entire length.
3. Mount switches outside of airstream at a location and mounting height to provide easy access for switch set-point adjustment and manual reset.
4. Install on entering side of cooling coil unless otherwise indicated on Drawings.

I. Liquid Temperature Sensor Installation:

1. Assembly shall include sensor, thermowell.

2. For pipe NPS 4 and larger, install sensor and thermowell length to extend into pipe between 50 to 75 percent of pipe cross section.
3. For pipe smaller than NPS 4:

    a. Install reducers to increase pipe size to NPS 4at point of thermowell installation.
    b. For pipe sizes NPS 2-1/2 and NPS 3, thermowell and sensor may be installed at pipe elbow or tee to achieve manufacturer-recommended immersion depth in lieu of increasing pipe size.
    c. Minimum insertion depth shall be 2-1/2 inches.

4. Install matching thermowell.
5. Fill thermowell with heat-transfer fluid before inserting sensor.
6. Tip of spring-loaded sensors shall contact inside of thermowell.
7. For insulated piping, install thermowells with extension neck to extend beyond face of insulation.
8. Install thermowell in top dead center of horizontal pipe positioned in an accessible location to allow for inspection and replacement. If top dead center location is not possible due to field constraints, install thermowell at location along top half of pipe.
9. For applications with transmitters, mount transmitter remote from sensor in an accessible and serviceable location from floor.

3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification.

3.5 CLEANING

A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.

B. Wash and shine glazing.

C. Polish glossy surfaces to a clean shine.

3.6 CHECK-OUT PROCEDURES

A. Check installed products before continuity tests, leak tests, and calibration.

B. Check temperature instruments for proper location and accessibility.

C. Verify sensing element type and proper material.

D. Verify location and length.

E. Verify that wiring is correct and secure.

3.7 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.8 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain temperature instruments.

END OF SECTION 230923.27

SECTION 232113 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes pipe and fitting materials and joining methods for the following:

1. Steel pipe and fittings.
2. Joining materials.
3. Transition fittings.
4. Dielectric fittings.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of the following:

1. Pipe.
2. Fittings.
3. Joining materials.

1.3 QUALITY ASSURANCE

A. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:

1. Hot-Water Heating Piping: 100 psig at 200 deg F.
2. Chilled-Water Piping: 150 psig at 73 deg F.

2.2 COPPER TUBE AND FITTINGS

A. -Temper Copper Tubing: ASTM B 88, Type L and ASTM B 88, Type M as scheduled.

B. Annealed-Temper Copper Tubing: ASTM B 88, Type K.

C. Wrought-Copper Unions: ASME B16.22.

2.3 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; welded and seamless, Grade B, and wall thickness as indicated in "Piping Applications" Article.

B. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

C. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

1. Material Group: 1.1.
2. End Connections: Butt welding.
3. Facings: Raised face.

2.4 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless otherwise indicated.

a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

C. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

D. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

E. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.5 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:
1. Description:

a. Standard: ASSE 1079.
b. Pressure Rating: 125 psig minimum at 180 deg F.
c. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:

1. Description:

a. Standard: ASSE 1079.

b. Factory-fabricated, bolted, companion-flange assembly.
c. Pressure Rating: 150 psig.
d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Hot-water heating piping, aboveground, NPS 2 and smaller, shall be any of the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
2. Schedule 40, Grade B steel pipe; Class 125, cast-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

B. Hot-water heating piping, aboveground, NPS 2-1/2 and larger, shall be any of the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and brazed joints.
2. Schedule 40 steel pipe, wrought-steel fittings and forged-steel flanges and flange fittings, and welded and flanged joints.

C. Chilled-water piping, aboveground, NPS 2 and smaller, shall be the following:
1. Schedule 40 steel pipe; Class 125, cast-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

D. Chilled-water piping, aboveground, NPS 2-1/2 and larger, shall be the following:
1. Schedule 40 steel pipe, wrought-steel fittings and forged-steel flanges and flange fittings, and welded and flanged joints.

E. Condensate-Drain Piping: Type M, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

F. Air-Vent Piping:

1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.
2. Outlet: Type K, annealed-temper copper tubing with soldered or flared joints.

3.2 PIPING INSTALLATIONS

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Install piping to allow application of insulation.

J. Select system components with pressure rating equal to or greater than system operating pressure.

K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

L. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

O. Install branch connections to mains using tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.

P. Install valves according to the following:

1. Section 230523.12 "Ball Valves for HVAC Piping."
2. Section 230523.13 "Butterfly Valves for HVAC Piping."

Q. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

R. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

S. Install shutoff valve immediately upstream of each dielectric fitting.

T. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.

U. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

V. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.3 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric unions.

C. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges.

D. Dielectric Fittings for NPS 5 and Larger: Use dielectric flanges.

3.4 HANGERS AND SUPPORTS

A. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hangers, supports, and anchor devices..

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

C. Install hangers for copper tubing and steel piping, with maximum horizontal spacing and minimum rod diameters, to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

D. Support vertical runs of copper tubing and steel piping to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

E. Install hangers for plastic piping, with maximum horizontal spacing and minimum rod diameters, to comply with manufacturer's written instructions, locally enforced code, and authorities having jurisdiction requirements, whichever are most stringent.

F. Support horizontal piping within 12 inches of each fitting and coupling

3.5 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8/A5.8M.

E. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

F. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.6 TERMINAL EQUIPMENT CONNECTIONS

A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install control valves in accessible locations close to connected equipment.

C. Install ports for pressure gages and thermometers at coil inlet and outlet connections. Comply with requirements in Section 230519 "Meters and Gages for HVAC Piping."

3.7 CHEMICAL TREATMENT

A. Fill system with fresh water and add liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products from piping. Circulate solution for a minimum of 24 hours, drain, clean strainer screens, and refill with fresh water.

B. Add initial chemical treatment and maintain water quality for the first year of operation.

3.8 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

C. Perform the following before operating the system:

1. Open manual valves fully.
2. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
3. Set temperature controls so all coils are calling for full flow.

END OF SECTION 232113

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 232116 - HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Hydronic specialty valves. Air-control devices.
2. Strainers.

B. Related Requirements:

1. Section 230523.12 "Ball Valves for HVAC Piping" for specification and installation requirements for ball valves common to most piping systems.
2. Section 230523.13 "Butterfly Valves for HVAC Piping" for specification and installation requirements for butterfly valves common to most piping systems.
3. Section 230923.11 "Control Valves" for automatic control valve and sensor specifications, installation requirements, and locations.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product:

1. Include construction details and material descriptions for hydronic piping specialties.
2. Include rated capacities, operating characteristics, and furnished specialties and accessories.
3. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 HYDRONIC SPECIALTY VALVES

A. Bronze, Calibrated-Orifice, Balancing Valves:
1. Body: Bronze, ball or plug type with calibrated orifice or venturi.
2. Ball: Brass or stainless steel.
3. Plug: Resin.
4. Seat: PTFE.
5. End Connections: Threaded or socket.
6. Pressure Gage Connections: Integral seals for portable differential pressure meter.
7. Handle Style: Lever, with memory stop to retain set position.

8. CWP Rating: Minimum 125 psig.
9. Maximum Operating Temperature: 250 deg F.

2.2 AIR-CONTROL DEVICES

A. Manual Air Vents:
1. Body: Bronze.
2. Internal Parts: Nonferrous.
3. Operator: Screwdriver or thumbscrew.
4. Inlet Connection: NPS 1/2.
5. Discharge Connection: NPS 1/8.
6. CWP Rating: 150 psig.
7. Maximum Operating Temperature: 225 deg F.

2.3 STRAINERS

A. Y-Pattern Strainers:

1. Body: ASTM A126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: Stainless-steel, 20-mesh strainer, or perforated stainless-steel basket.
4. CWP Rating: 125 psig.

PART 3 - EXECUTION

3.1 HYDRONIC SPECIALTIES INSTALLATION

A. Install air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting. Use manual air vents when installed above ceilings and in occupied areas. Use automatic air vents piped to drain in mechanical equipment rooms.

END OF SECTION 232116

SECTION 233113 - METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Single-wall rectangular ducts and fittings.
2. Single-wall round ducts and fittings.
3. Sheet metal materials.
4. Duct liner.
5. Sealants and gaskets.
6. Hangers and supports.

B. Related Sections:
1. Section 230713 "Duct Insulation."
2. Section 233300 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.3 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.

B. Structural Performance: Duct hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible".

C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of the following products:

1. Liners and adhesives.
2. Sealants and gaskets.
3. Leakage Test Reports.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
2. Suspended ceiling components.
3. Structural members to which duct will be attached.
4. Size and location of initial access modules for acoustical tile.
5. Penetrations of smoke barriers and fire-rated construction.
6. Items penetrating finished ceiling including the following:

a. Lighting fixtures.
b. Air outlets and inlets.
c. Speakers.
d. Sprinklers.
e. Access panels.
f. Perimeter moldings.

B. Welding certificates.

C. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
2. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

PART 2 - PRODUCTS

2.1 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.2 SINGLE-WALL ROUND DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.

D. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G90.
2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

D. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.4 DUCT LINER

A. Fibrous-Glass Duct Liner: Comply with ASTM C1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

1. Maximum Thermal Conductivity:

a. Type I, Flexible: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.

2. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
3. Solvent-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C916.

a. Adhesive shall have a VOC content of 80 g/L or less.

B. Insulation Pins and Washers:

1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch-diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick galvanized steel; with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

C. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 7-11, "Flexible Duct Liner Installation."

1. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
2. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
3. Butt transverse joints without gaps, and coat joint with adhesive.
4. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
5. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.
6. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm.
7. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
8. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:

a. Fan discharges.
b. Intervals of lined duct preceding unlined duct.

c. Upstream edges of transverse joints in ducts where air velocities are higher than 2500 fpm or where indicated.

9. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

2.5 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

C. Flanged Joint Sealant: Comply with ASTM C 920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.

D. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

2.6 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.

F. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

H. Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install round ducts in maximum practical lengths.

D. Install ducts with fewest possible joints.

E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Section 233300 "Air Duct Accessories" for fire and smoke dampers.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials."

3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum interval of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.5 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:

1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
2. Leakage tests shall be witnessed by Owner's representative and/or Authority Having Jurisdiction
3. Duct leakage test shall be performed on all supply, return, and exhaust air ductwork except for supply air ductwork downstream of the terminal units (mixing boxes).
4. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
5. Test for leaks before applying external insulation.
6. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
7. Give seven days' advance notice for testing.

C. Duct System Cleanliness Tests:

1. Visually inspect duct system to ensure that no visible contaminants are present.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.7 DUCT CLEANING

A. Clean new duct system(s) before testing, adjusting, and balancing.

B. Use service openings for entry and inspection.

1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 233300 "Air Duct Accessories" for access panels and doors.
2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling to gain access during the cleaning process.

C. Particulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

D. Clean the following components by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).

2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.
5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.
7. Dedicated exhaust and ventilation components and makeup air systems.

E. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans according to NADCA ACR. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for wash-down procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

3.8 START UP

A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.9 SINGLE WALL DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel except as otherwise indicated:

B. Supply Ducts:

1. Ducts Connected to Fan Coil Units and Terminal Units:

a. Pressure Class: Positive 1-inch wg.
b. Minimum SMACNA Seal Class: A.
c. SMACNA Leakage Class for Rectangular: 24.
d. SMACNA Leakage Class for Round and Flat Oval: 12.

2. Ducts Connected to Air-Handling Units Enclosed in Inaccessible Areas:

a. Pressure Class: Positive 3-inch wg.

b. Minimum SMACNA Seal Class: A.
c. SMACNA Leakage Class for Rectangular: 6.
d. SMACNA Leakage Class for Round and Flat Oval: 3.

3. Ducts Connected to Constant-Volume Air-Handling Units above Accessible Ceilings and Other Accessible Areas:

a. Pressure Class: Positive 3-inch wg.
b. Minimum SMACNA Seal Class: A.
c. SMACNA Leakage Class for Rectangular: 12.
d. SMACNA Leakage Class for Round and Flat Oval: 6.

C. Return Ducts:

1. Ducts Connected to Fan Coil Units:

a. Pressure Class: Positive or negative 1-inch wg.
b. Minimum SMACNA Seal Class: A.
c. SMACNA Leakage Class for Rectangular: 24.
d. SMACNA Leakage Class for Round and Flat Oval: 12.

2. Ducts Connected to Air-Handling Units Enclosed in Risers and Other Inaccessible Areas:

a. Pressure Class: Positive or negative 3-inch wg.
b. Minimum SMACNA Seal Class: A.
c. SMACNA Leakage Class for Rectangular: 6.
d. SMACNA Leakage Class for Round and Flat Oval: 3.

3. Ducts Connected to Air-Handling Units above Accessible Ceilings and Other Accessible Areas:

a. Pressure Class: Positive or negative 3-inch wg.
b. Minimum SMACNA Seal Class: A.
c. SMACNA Leakage Class for Rectangular: 12.
d. SMACNA Leakage Class for Round and Flat Oval: 6.

D. Exhaust Ducts:

1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:

a. Pressure Class: Negative 2-inch wg.
b. Minimum SMACNA Seal Class: A if negative pressure, and A if positive pressure.
c. SMACNA Leakage Class for Rectangular: 12
d. SMACNA Leakage Class for Round and Flat Oval: 6.

E. Intermediate Reinforcement:

1. Galvanized-Steel Ducts: Galvanized steel or carbon steel coated with zinc-chromate primer.

F. Liner:

1. Indoor, Concealed Transfer Air Ducts and Plenums: Fibrous glass, Type I, 1 inch thick.

G. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

    a. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

2. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."

    a. Minimum Radius-to-Diameter Ratio:

        1) Radius-to Diameter Ratio: 1.5.

    b. Round Elbows: Standing seam for galvanized application, Welded for stainless steel applications.

END OF SECTION 233113

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 233300 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Manual volume dampers.
2. Flange connectors.
3. Turning vanes.
4. Duct-mounted access doors.
5. Flexible connectors.
6. Flexible ducts

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 MATERIALS

A. Galvanized Sheet Steel: Comply with ASTM A653/A653M.

1. Galvanized Coating Designation: G90.
2. Exposed-Surface Finish: Mill phosphatized.

B. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

C. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:

1. Standard leakage rating.
2. Suitable for horizontal or vertical applications.
3. Frames:

    a. Frame: Hat-shaped, 0.094-inch-thick, galvanized sheet steel.
    b. Mitered and welded corners.
    c. Flanges for attaching to walls and flangeless frames for installing in ducts.

4. Blades:

    a. Multiple or single blade.
    b. Parallel- or opposed-blade design.
    c. Stiffen damper blades for stability.
    d. Galvanized-steel, 0.064 inch thick.

5. Blade Axles: Galvanized steel.
6. Bearings:

    a. Oil-impregnated bronze.
    b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

7. Tie Bars and Brackets: Galvanized steel.

B. Jackshaft:

1. Size: 0.5-inch diameter.
2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

C. Damper Hardware:

1. Zinc-plated, die-cast core with dial and handle made of 3/32-inch-thick zinc-plated steel, and a 3/4-inch hexagon locking nut.
2. Include center hole to suit damper operating-rod size.
3. Include elevated platform for insulated duct mounting.

2.4 FLANGE CONNECTORS

A. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.

B. Material: Galvanized steel.

C. Gage and Shape: Match connecting ductwork.

2.5 TURNING VANES

A. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

B. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."

C. Vane Construction: Double wall.

2.6 DUCT-MOUNTED ACCESS DOORS

A. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2, "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."

1. Door:

a. Double wall, rectangular.
b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
c. Vision panel.
d. Hinges and Latches: 1-by-1-inchbutt or piano hinge and cam latches.
e. Fabricate doors airtight and suitable for duct pressure class.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
3. Number of Hinges and Locks:

a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
b. Access Doors up to 18 Inches Square: Continuous and two sash locks.
c. Access Doors up to 24 by 48 Inches: Continuous and two compression latches.
d. Access Doors Larger Than 24 by 48 Inches: Continuous and two compression latches with outside and inside handles.

2.7 FLEXIBLE CONNECTORS

A. Materials: Flame-retardant or noncombustible fabrics.

B. Coatings and Adhesives: Comply with UL 181, Class 1.

C. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches wide attached to two strips of 2-3/4-inch-wide, 0.028-inch-thick, galvanized sheet steel or 0.032-inch-thick aluminum sheets. Provide metal compatible with connected ducts.

D. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 26 oz./sq. yd..
2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
3. Service Temperature: Minus 40 to plus 200 deg F.

2.8 FLEXIBLE DUCTS

A. Manufacturers: Subject to compliance with requirements, provide products by the following or approved equal:

1. Thermaflex (M-KC line, Basis of Design).

B. Insulated, Flexible Duct: UL 181, Class 1, woven and coated fiberglass film supported by helically wound, spring-steel wire; fibrous-glass insulation; fiberglass reinforced metalized film laminate vapor barrier.

1. Pressure Rating: 10-inch wg positive and 2-inch wg negative.
2. Maximum Air Velocity: 6000 fpm.
3. Temperature Range: Minus 20 to plus 250 deg F.
4. Insulation R-value: Comply with ASHRAE/IESNA 90.1.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.

1. Install steel volume dampers in steel ducts.

D. Set dampers to fully open position before testing, adjusting, and balancing.

E. Install fire and smoke dampers according to UL listing.

F. Install access doors with swing against duct static pressure.

G. Access Door Sizes:

1. One-Hand or Inspection Access: 8 by 5 inches.
2. Two-Hand Access: 12 by 6 inches.

3. Head and Hand Access: 18 by 10 inches.
4. Head and Shoulders Access: 21 by 14 inches.
5. Body Access: 25 by 14 inches.
6. Body plus Ladder Access: 25 by 17 inches.

H. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

I. Install flexible connectors to connect ducts to equipment.

J. Connect terminal units to supply ducts directly or with maximum 12-inch lengths of flexible duct. Do not use flexible ducts to change directions.

K. Connect diffusers or light troffer boots to ducts with maximum 48-inch lengths of flexible duct clamped or strapped in place.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Operate fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation.

END OF SECTION 233300

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 233600 - AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Shutoff, single-duct air terminal units.
2. Casing liner.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of air terminal unit.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

2.2 SHUTOFF, SINGLE-DUCT AIR TERMINAL UNITS

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

1. Krueger
2. Nailor Industries Inc
3. Price Industries (Basis of Design)
4. Titus

B. Configuration: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.

C. Casing: 0.040-inch- thick galvanized steel, single wall.

1. Casing Liner: Comply with requirements in "Casing Liner" Article for flexible elastomeric duct liner.
2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
3. Air Outlet: S-slip and drive connections.
4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: AHRI 880 rated, 2 percent of nominal airflow at 3-inch wg inlet static pressure.
2. Damper Position: Normally open.

E. Hydronic Heating Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain valve.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 5, "Hangers and Supports" and with Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Hangers Exposed to View: Threaded rod and angle or channel supports.

C. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.2 TERMINAL UNIT INSTALLATION

A. Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

B. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

C. Where installing piping adjacent to air terminal unit, allow space for service and maintenance.

D. Hot-Water Piping: Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties," and connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.

E. Comply with requirements in Section 233113 "Metal Ducts" for connecting ducts to air terminal units.

F. Make connections to air terminal units with flexible connectors complying with requirements in Section 233300 "Air Duct Accessories."

G. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for equipment labels and warning signs and labels.

3.3 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain air terminal units.

END OF SECTION 233600

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 237313.16 - INDOOR, SEMI-CUSTOM AIR-HANDLING UNITS

1.1 SUMMARY

A. Section includes insulated, double-wall-casing, indoor, semi-custom air-handling units that are factory assembled using multiple section components, including the following:

1. Casings.
2. Fans, drives, and motors.
3. Coils.
4. Air filtration.
5. Dampers.

1.2 ACTION SUBMITTALS

A. Product Data: For each air-handling unit.

B. Shop Drawings: For each type and configuration of indoor, semi-custom air handling unit.

1. Include plans, elevations, sections, and details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-handling units to include in emergency, operation, and maintenance manuals.

1.4 WARRANTY

A. Warranty: Manufacturer agrees to repair or replace components of indoor, semi-custom air-handling units that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 5 year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.

C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

D. Structural Performance: Casing panels shall be self-supporting and capable of withstanding positive/negative 8-inch wg of internal static pressure, without exceeding a midpoint deflection of 0.0042 inch/inch of panel span.

E. Casing Leakage Performance: ASHRAE 111, Class 9 leakage or better at plus or minus 8 inch wg.

2.2 MANUFACTURERS

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

1. Carrier Corporation
2. Trane (Basis of Design)
3. YORK

2.3 UNIT CASINGS

A. Frame: Providing overall structural integrity without reliance on casing panels for structural support.

B. Casing Joints: Hermetically sealed at each corner and around entire perimeter.

C. Double-Wall Construction:

1. Outside Casing Wall:

a. Material, Galvanized Steel: Of thickness suitable to provide stated deflection performance, but no less than 22 gauge.
b. Factory Finish: Provide manufacturer's standard finish.

2. Inside Casing Wall:

a. Material, Galvanized Steel: Solid, minimum 18 gauge thick.

D. Floor Plate:

1. Material, Galvanized Steel: of sufficient thickness to deflect no more than 0.0042 inch per inch of panel span.

E. Casing Insulation:

1. Materials: Injected polyurethane foam insulation.
2. Casing Panel R-Value: Minimum R-13.
3. Insulation Thickness: 2 inches.
4. Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roofs of air-handling unit.

F. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.

G. Doors, and Windows:

1. Doors:

   a. Fabrication: Formed and reinforced, double-wall and insulated panels of same materials and thicknesses as casing.
   b. Hinges: A minimum of two ball-bearing hinges or stainless-steel piano hinge and two wedge-lever latches, operable from inside and outside. Arrange doors to be opened against airflow. Provide safety latch retainers on doors so that doors do not open uncontrollably.
   c. Gasket: Neoprene, applied around entire perimeters of panel frames.
   d. Size: Large enough to allow for unobstructed access for inspection and maintenance of air-handling unit's internal components. At least 24 inches wide by full height of unit casing up to a maximum height of 84inches.

2. Windows:

   a. Construction: Fabricate windows in access panels and doors of double-glazed, safety glass with an airspace between panes and sealed with interior and exterior rubber seals.
   b. Size: Minimum 6 inches, square or round.

3. Locations and Applications:

   a. Filter Access Section: Door with window

   b. Access Section between Preheat and Cooling Coils: Door with window

   c. Access Section between Cooling Coil and Fan Inlet: Door with window

   d. Access Section at Fan Discharge: Door with window

4. Service Lights: LED vaporproof luminaire with individual switched junction box located outside, adjacent to each access door and panel.

   a. Locations: Each section accessed with door or panel.

5. Convenience Outlets: One 20-A duplex GFCI receptacle per location with junction box located on outside casing wall.

   a. Locations: Minimum one each side of the unit.

H. Condensate Drain Pans:

1. Construction:

   a. Single-wall, stainless-steel sheet.

2. Drain Connection:

   a. Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.
   b. Minimum Connection Size: sized per IMC-2018.

3. Slope: Minimum 0.125-in./ft. slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and from humidifiers and to direct water toward drain connection.
4. Length: Extend drain pan downstream from leaving face for distance to comply with ASHRAE 62.1.
5. Width: Entire width of water producing device.
6. Depth: A minimum of 2 inches deep.
7. Formed sections or integral part of floor plating.
8. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

2.4 FAN, DRIVE, AND MOTOR SECTION

A. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.

B. Fans: Centrifugal, rated according to AMCA 210; galvanized steel; mounted on solid-steel shaft.

1. Shafts: With field-adjustable alignment.

a. Turned, ground, and polished hot-rolled steel with keyway.

2. Shaft Bearings:

a. Prelubricated and Sealed, Ball Bearings: Self-aligning, pillow-block type with an L-50 rated life of 200,000 hours according to ABMA 9.

3. Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.

a. Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.

4. Housings, Plenum Fans: Steel frame and panel; fabricated without fan scroll and volute housing. Provide inlet screens for Type SWSI fans.
5. Airfoil, Centrifugal Fan Wheels (Plenum Fan Wheels): Smooth-curved inlet flange, backplate, and hollow die-formed airfoil-shaped blades continuously welded at tip flange and backplate; steel hub riveted to backplate and fastened to shaft with setscrews.
6. Mounting: For internal vibration isolation. Factory-mount fans with manufacturer's standard vibration isolation mounting devices having a minimum static deflection of 1 inch.
7. Shaft Lubrication Lines: Extended to a location outside the casing.
8. Flexible Connector: Factory fabricated with a fabric strip minimum 3-1/2 inches wide, attached to two strips of minimum 2-3/4-inch-wide by 0.028-inch-thick, galvanized-steel sheet.

a. Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives shall comply with UL 181, Class 1.

1) Fabric Minimum Weight: 26 oz./sq. yd..
2) Fabric Minimum Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
3) Fabric Minimum Service Temperature Range: Minus 40 to plus 200 deg F.

C. Drive, Direct: Factory-mounted, direct drive.

D. Motors:

1. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Enclosure Type: Open, dripproof.
3. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.

E. Variable-Frequency Motor Controller: Comply with Section 262923 "Variable-Frequency Motor Controllers."

2.5 COIL SECTION

A. General Requirements for Coil Section:

1. Comply with AHRI 410.
2. Fabricate coil section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
3. Coils shall not act as structural component of unit.

B. Heating Coils:

1. Hot-Water Coils: Continuous circuit.

a. Piping Connections: Threaded or Flanged, same end of coil.
b. Tube Material: Copper.
c. Fin Type: Plate.
d. Fin Material: Aluminum.
e. Headers:

1) Cast iron with cleaning plugs and drain and air vent tappings.
2) Seamless copper tube with brazed joints, prime coated.
3) Fabricated steel, with brazed joints, prime coated.
4) Provide insulated cover to conceal exposed outside casings of headers.

f. Frames: Channel frame, 0.052-inch-thick, galvanized steel.
g. Coil Working-Pressure Ratings: 200 psig, 325 deg F.

C. Cooling Coils:

1. Chilled-Water Coil: Continuous circuit.

a. Piping Connections: Flanged, same end of coil.
b. Tube Material: Copper.
c. Fin Type: Plate.
d. Fin Material: Aluminum.
e. Headers:

1) Cast iron with cleaning plugs and drain and air vent tappings.
2) Seamless copper tube with brazed joints, prime coated.

3) Fabricated steel, with brazed joints, prime coated.
4) Provide insulated cover to conceal exposed outside casings of headers.

f. Frames: Channel frame, 0.052-inch-thick, galvanized steel.
g. Working-Pressure Ratings: 200 psig, 325 deg F.

2.6 AIR FILTRATION SECTION

A. Panel Filters:

1. Description: Pleated factory-fabricated, self-supported, disposable air filters with holding frames.
2. Filter Unit Class: UL 900.
3. Media: Interlaced glass, synthetic or cotton fibers coated with nonflammable adhesive.

B. Bag Filters:

1. Description: Factory-fabricated, dry, extended-surface, self-supporting filters with holding frames in steel, basket-type retainers.
2. Filter Unit Class: UL 900.
3. Media: Fibrous material, coated with antimicrobial agent, constructed so individual pockets are maintained in tapered form by flexible internal supports under rated-airflow conditions.
4. Filter-Media Frame: Galvanized steel.

C. Cartridge Filters:

1. Description: Factory-fabricated, disposable, packaged air filters with media perpendicular to airflow, and with holding frames.
2. Filter Unit Class: UL 900.
3. Media: Fibrous material, coated with antimicrobial agent, constructed so individual pleats are maintained in pleated form under rater-airflow conditions by corrugated aluminum separators.
4. Filter Media Frame: Galvanized steel.

D. Back-Access Filter Mounting Frames:
1. Particulate Air Filter Frames: Galvanized-steel framing members with access for filter servicing, cut to size and prepunched for assembly into modules. Vertically support filters to prevent deflection of horizontal members without interfering with either filter installation or operation.

a. Prefilters: Incorporate a separate track with spring clips, with same access as primary filter.
b. Sealing: Full periphery foam gaskets.

2.7 DAMPERS

A. Dampers: Comply with requirements in Section 230923.12 "Control Dampers."

2.8 MATERIALS

A. Steel:

1. ASTM A36/A36M for carbon structural steel.

2. ASTM A568/A568M for steel sheet.

B. Stainless Steel:

1. Manufacturer's standard grade for casing.
2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.

C. Galvanized Steel: ASTM A653/A653M.

D. Aluminum: ASTM B209.

2.9 SOURCE QUALITY CONTROL

A. AHRI 430 Certification: Air-handling units and their components shall be factory tested according to AHRI 430 and shall be listed and labeled by AHRI.

B. AMCA 301 or AHRI 260: Air-handling unit fan sound ratings shall comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data," or AHRI 260, "Sound Rating of Ducted Air Moving and Conditioning Equipment."

C. Fan Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Fans shall bear AMCA-certified sound ratings seal.

D. Fan Performance Rating: Factory test fan performance for airflow, pressure, power, air density, rotation speed, and efficiency. Rate performance according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating."

E. Water Coils: Factory tested to 300 psig according to AHRI 410 and ASHRAE 33.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Examine roughing-in for hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.

B. Arrange installation of units to provide access space around air-handling units for service and maintenance.

C. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.

D. Install filter-gauge, static-pressure taps upstream and downstream of filters. Mount filter gauges on outside of filter housing or filter plenum in accessible position. Provide filter gauges on filter banks, installed with separate static-pressure taps upstream and downstream of filters. Each filter bank shall have separate gauges.

E. Connect duct to air-handling units with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."

3.2 PIPING CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to air-handling unit, allow for service and maintenance.

C. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.

D. Connect condensate drain pans using ASTM B88, Type M copper tubing, minimum size per IMC-2018. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

E. Hot- and Chilled-Water Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.

3.3 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
   1. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.4 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

   1. Leak Test: After installation, fill water and steam coils with water, and test coils and connections for leaks.
   2. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.

C. Prepare test and inspection reports.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain air-handling units.

END OF SECTION 237313.16

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 238219 - FAN COIL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

1.2 SUMMARY

A. Section Includes:

1. Ducted fan coil units and accessories.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, and furnished specialties and accessories.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fan coil units to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Comply with NFPA 70.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.6 COORDINATION

A. Coordinate layout and installation of fan coil units and suspension system components with other construction that penetrates or is supported by ceilings, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Factory-packaged and -tested units rated according to AHRI 440, ASHRAE 33, and UL 1995.

2.2 DUCTED FAN COIL UNITS

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

1. Carrier Corporation
2. Trane (Basis of Design)
3. YORK

B. Coil Section Insulation: 1-inch-thick, coated glass fiber complying with ASTM C1071 and attached with adhesive complying with ASTM C916.

1. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E84 by a qualified testing agency.
2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Drain Pans: Stainless steel or insulated galvanized steel with plastic liner. Fabricate pans and drain connections to comply with ASHRAE 62.1.

D. Chassis: Galvanized steel where exposed to moisture. Floor-mounting units shall have leveling screws.

E. Cabinets: Steel with baked-enamel finish in manufacturer's standard paint color.

1. Supply-Air Plenum: Sheet metal plenum finished and insulated to match the chassis.
2. Return-Air Plenum: Sheet metal plenum finished to match the chassis.
3. Dampers: Galvanized steel with extruded-vinyl blade seals, flexible-metal jamb seals, and interlocking linkage.

F. Filters: Minimum arrestance and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2 and all addendums.

G. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain.

H. Direct-Driven Fans: Double width, forward curved, centrifugal; with permanently lubricated, multispeed motor resiliently mounted in the fan inlet. Aluminum or painted-steel wheels, and painted-steel or galvanized-steel fan scrolls.

1. Motors: Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

I. Electrical Connection: Factory wire motors and controls for a single electrical connection.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, with Installer present, to receive fan coil units for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping and electrical connections to verify actual locations before fan coil unit installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install fan coil units level and plumb.

B. Install fan coil units to comply with NFPA 90A.

C. Suspend fan coil units from structure with elastomeric hangers.

D. Install new filters in each fan coil unit within two weeks after Substantial Completion.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:

1. Install piping adjacent to machine to allow service and maintenance.
2. Connect condensate drain to indirect waste.

    a. Install condensate trap of adequate depth to seal against fan pressure. Install cleanouts in piping at changes of direction.

B. Connect supply-air and return-air ducts to fan coil units with flexible duct connectors specified in Section 233300 "Air Duct Accessories." Comply with safety requirements in UL 1995 for duct connections.

C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Remove and replace malfunctioning units and retest as specified above.

C. Prepare test and inspection reports.

3.5 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain fan coil units.

END OF SECTION 238219

SECTION 260050 - BASIC ELECTRICAL METHODS AND REQUIREMENTS

PART 1 GENERAL

1.1 DESCRIPTION:

A. Furnish and install all electrical wiring, systems, equipment and accessories in accordance with the specifications and drawings. Capacities and ratings of transformers, cable, switchgear, panelboards, etc., and arrangement for specified items in general are shown on drawings. Drawings indicate the general arrangement of the systems and are diagrammatic and do not necessarily show the exact locations of equipment. Any major system rearrangement required by field conditions shall be approved by the Architect/Engineer before work is started.

B. All ampacities herein specified or indicated on the drawings are based on copper conductors, with the conduit and raceways accordingly sized. Aluminum conductors are not permitted.

1.2 MINIMUM REQUIREMENTS:

A. References to the National Electrical Code (NEC), Underwriters Laboratories, Inc. (UL), and National Fire Protection Association (NFPA) (latest editions as adopted by Pima County are a minimum installation standard.

C. All work shall comply with the requirements of Pima County Facilities Management Electrical Standards

D. Design drawings and other specification sections shall govern in those instances where requirements are greater than those specified in NEC. A copy of NFPA 70, (NEC), latest edition, shall be available at the job site at all times.

1.3 DRAWINGS:

A. The Contractor shall be responsible for determining how to fit all conduit, wiring, etc., into or below the structure, and shall not make additional charges for work required to install the indicated work in a proper manner.

B. The plans and specifications are complimentary and anything indicated by either shall be required to be installed as if it were indicated on both.

C. All work shall be installed and coordinated with all other trades. Conflicts shall be solved through a joint decision by the trades and shall be presented to the Architect/Engineer for their approval.

1.4 INTERPRETATION OR CORRECTION OF BIDDING DOCUMENTS:

A. It is the responsibility of the Contractor to visit the site prior to bid. At least 7 calendar days prior to bid, bidders shall notify the Architect/Engineer promptly of any ambiguity, inconsistency or error discovered upon examination of Bidding Documents or of site and local conditions. Failure to notify the Architect/Engineer is deemed a waiver of any claim by the Contractor based upon any such ambiguity, inconsistency or errors. The Architect/Engineer shall maintain a log of all inquiries and shall provide written notification of such to the Owner.

1.5 STANDARDS:

A. All material and equipment shall be listed, labeled or certified by Underwriters Laboratories Inc., for the use specified herein, where such standards have been established. Equipment and material which is not covered by UL Standards, will be accepted provided equipment and material is listed, labeled, certified or otherwise determined to meet safety requirements of a nationally recognized testing laboratory. Equipment of a class, which no nationally recognized testing laboratory accepts, certifies, lists, labels or determines to be safe, will be considered if inspected or tested in accordance with national industrial standards, such as NEMA, or ANSI. Evidence of compliance shall include certified test reports and definitive shop drawings.

B. Definitions:

1. Listed: Equipment is "listed" if of a kind mentioned in a list which:

   a. Is published by a nationally recognized laboratory, which makes periodic inspection of production of such equipment.
   b. States that such equipment meets nationally recognized standards or has been tested and found safe for use in a specified manner.

2. Labeled: Equipment is labeled if:

   a. It embodies a valid label, symbol, or other identifying mark of a nationally recognized testing laboratory such as Underwriters Laboratories, Inc.
   b. The laboratory makes periodic inspections of the production of such equipment.
   c. The labeling indicates compliance with nationally recognized standards or tests to determine safe use in a specified manner.

3. Certified: Equipment is "certified" if:

   a. Equipment has been tested and found by a nationally recognized testing laboratory to meet nationally recognized standards or to be safe for use in a specified manner.
   b. Production is periodically inspected by a nationally recognized testing laboratory.
   c. It bears a label, tag, or other record of certification.

4. Nationally recognized testing laboratory: A testing laboratory which is approved, in accordance with OSHA regulations, by the Secretary of Labor.

1.6 QUALIFICATIONS (PRODUCTS AND SERVICES):

A. Manufacturers Qualifications: The manufacturer shall regularly and presently produce, as one of the manufacturer's principal products, the equipment and material specified for this project, and shall have manufactured the item for at least five years.

B. Product Qualification:

1. Manufacturer's product shall have been in satisfactory operation on three installations of similar size and type, as this project, for approximately three years.
2. The Architect/Engineer reserves the right to require the Contractor to submit a list of installations where the products have been in operation before approval.

C. Service Qualifications: There shall be a permanent service organization maintained or trained by the manufacturer which will render satisfactory service to this installation within four hours of receipt of notification that service is needed. Submit name and address of service organizations.

1.7 WARRANTY:

A. Fully guarantee all work under this section for a 1 year period. Work found to be defective within this period shall be replaced without cost to the Owner.

B. In addition to the project warranty, all equipment installed shall be guaranteed to meet specified performance and warranty requirements, and to operate without excessive noise or vibration.

PART 2 PRODUCTS

2.1 MANUFACTURED PRODUCTS:

A. The manufacturer(s) and catalog numbers specified are to establish design intent and level of quality. Equal products of other manufacturers may be submitted for prior approval.

B. Materials and equipment furnished shall be of current production by manufacturers regularly engaged in the manufacture of such items, for which replacement parts shall be available. Items not meeting this requirement, but which otherwise meet technical specifications, and merits of which can be established through reliable test reports or physical examination of representative samples, will be considered.

C. When more than one unit of the same class of equipment is required, such units shall be the product of a single manufacturer.

D. Equipment Assemblies and Components:

1. All components of an assembled unit need not be products of the same manufacturer.
2. Manufacturers of equipment assemblies, which include components made by others, shall assume complete responsibility for the final assembled unit.
3. Components shall be compatible with each other and with the total assembly for the intended service.
4. Constituent parts, which are similar, shall be the product of a single manufacturer.

E. All factory wiring shall be identified on the equipment being furnished and on all wiring diagrams.

2.2 EQUIPMENT REQUIREMENTS:

A. Equipment voltage and phase ratings shall be in accordance with the requirements indicated on the drawings or as specified.

B. Prior to construction, written approval shall be obtained by the Contractor for any equipment that differs from the requirements of the drawings and specifications.

1. Where the products of specific manufacturers are specified, substitutions will not be accepted unless prior approval has been received from the Architect/Engineer.
2. The Contractor shall furnish drawings showing all installation details, shop drawings, technical data and other pertinent information as required.
3. Approval by the Architect/Engineer of the equal equipment does not relieve the Contractor of the responsibility of furnishing and installing the equipment at no additional cost to the Owner.

2.3 EQUIPMENT PROTECTION:

A. Equipment and material shall be protected during shipment and storage against physical damage, vandalism, dirt, moisture, cold and rain. Electronic equipment shall be protected in a relatively constant temperature and humidity environment, which will not degrade the equipment. No equipment shall be installed until it is certain than no normal damage shall occur to the equipment between the time it is installed and the end of the contract. All equipment whether installed or stored remains the property of the Contractor until Substantial Completion. All equipment, whether installed or on site awaiting installation, remains the property of the Contractor until the end of the contract.

B. During installation, equipment, controls, controllers, circuit protective devices, etc., shall be protected against entry of foreign matter; and be vacuum cleaned both inside and outside before testing, operating and painting.

C. Damaged equipment shall be, as determined by the Architect/Engineer, placed in first class operating condition or be returned to the source of supply for repair or replacement.

D. Painted surfaces shall be protected with factory installed removable heavy draft paper, sheet vinyl or equal.

E. Damaged paint on equipment and materials shall be refinished with the same quality of paint and workmanship as used by the manufacturer so repaired areas are not obvious.

F. Metallic tags shall not be used inside switchboards or panels.

2.4 SUBMITTALS:

A. The Architect/Engineer's approval shall be obtained for all equipment and material before delivery to the job site. Delivery, storage or installation of equipment or material, which has not had prior approval, will not be permitted at the job site.

B. Submittals shall be marked to show specification reference including the section and paragraph numbers. Submittals shall be legible and clearly identify equipment being submitted.

C. Submit each section separately.

D. All submittals shall include adequate descriptive literature, catalog cuts, shop drawings, certifications, and other data necessary for the Architect/Engineer to ascertain that the proposed equipment and materials comply with specification requirements.

E. Submittals for individual systems and equipment assemblies, which consist of more than one item or component, shall be made for the system or assembly as a whole.

F. Partial submittals, submittals not in the format required, or submittals that do not indicate specific materials where a catalog cut shows multiple models, sizes, and/or options and accessories, will not be considered for approval.

G. The submittals shall include the following:

1. Information that confirms compliance with contract requirements. Include the manufacturer's name, model or catalog numbers, catalog information, technical data sheets, shop drawings, pictures, nameplate data, certifications and test reports.

2. Elementary and interconnection wiring diagrams for communication and signal systems, control system and equipment assemblies. All terminal points and wiring shall be identified on wiring diagrams
3. Parts list which shall include those replacement parts recommended by the equipment manufacturer, quantity of parts, current price and availability of each part.
4. Manuals:

    a. Maintenance manuals shall be complete and shall be furnished in a loose-leaf binder or in the manufacturer's standard binder. Information shall be sufficient to enable a qualified technician to perform normal first line maintenance and repair.
    b. Operation manuals shall be clear and concise and shall describe, in detail, the information required to properly operate the equipment specified.

5. Approvals will be based on complete submission of manuals together with shop drawings.

2.5 SINGULAR NUMBER:

A. Where any device or part of equipment is referred to in these specifications in the singular number (such as "the switch"), such reference shall be deemed to apply to as many such devices as are required to complete the installation as shown on the drawings.

PART 3 EXECUTION

3.1 QUALIFICATIONS:

A. All work associated with the installation of electrical equipment at this site shall be accomplished by skilled workmen, which are experienced in the type of work for which they are to accomplish. The Contractor shall be licensed to do commercial or industrial electrical work. Each work crew shall consist of a maximum of one helper for each journeyman electrician.

3.2 EQUIPMENT INSTALLATION AND REQUIREMENTS:

A. Equipment location shall be as close as practical to locations shown on the drawings.

B. Working spaces shall not be less than specified in the National Electrical Code for all voltages specified.

1. The working clearances specified in the National Electrical Code, Article 110.26(A) shall be required at switchboards and switchgear of all voltages, motor control centers, panelboards, fused and non-fused disconnect switches, generators, motor starters and variable frequency drives, sectionalizing cabinets, metering compartments, and all other electrical components likely to be energized.

C. Inaccessible Equipment:

1. Where the Architect/Engineer and/or Owner determines that the Contractor has installed equipment not conveniently accessible for operation and maintenance, equipment shall be removed and reinstalled as directed at no additional cost to the Owner.
2. "Convenient accessibility" is defined as being capable of being reached without the use of ladders, (excepting equipment mounted in or above ceilings) or without climbing or crawling under or over obstacles such as motors, pumps, belt guards, transformers, valves, piping and ductwork.

D. Equipment and Material:

1. New equipment and material shall be installed, unless otherwise specified.
2. Equipment and material shall be designed to assure satisfactory operation and operating life for environmental conditions where being installed. NEC and other code requirements shall apply to the installation in areas requiring special protection as explosion-proof, watertight and weatherproof construction.
3. All electrical disconnects, starters, panels, devices and plates shall be installed plumb and true. All adjacent boxes shall be aligned and level.
4. All panelboards, disconnects, starters and equipment shall be mounted at a height to make testing and maintenance as easy as possible. In no case shall panelboards be mounted so that the maximum height of any circuit breaker or switch exceeds 78 inches (6'-6") above finished floor level or grade to the top of the breaker.

3.3 COORDINATION:

A. All work shall be installed and coordinated with all other trades. Conflicts shall be solved through a joint decision by the trades and shall be presented to the Architect/Engineer for approval.

B. Arrange, phase, and perform work to assure adequate services for the Owner at all times.

C. Coordinate locations of conduit, sleeves, inserts, hangers, and equipment with other trades. Locate conduit, sleeves, inserts, hangers and equipment out of the way of windows, doors, openings, and other services and utilities. All through-the-floor sleeves shall be stubbed up a minimum of 1" AFF, and shall be fire spread protected.

D. Pneumatic hammer, impact electric and hand or manual hammer type drills, will not be allowed. Holes shall be laid out in advance. If necessary to drill through structural sections, prior approval shall be obtained from the Architect/Engineer.

3.4 POWER SHUTDOWNS:

A. Prior notice of power shutdowns or disruptions shall be coordinated by the Contractor as directed by the Owner. Schedule for shutdown shall be provided to Owner for approval a minimum of 2 week prior to shutdown.

3.5 TEMPORARY ELECTRICAL SERVICE DURING CONSTRUCTION PERIOD:

A. The Contractor shall be responsible for all materials, labor, billing, applications, and fees necessary to establish a construction electrical power service.

3.6 TESTING:

A. Contractor shall test his work in sections. All defects shall be made good immediately at his expense, including all repairs to walls, ceilings, floors, or other portions of building damaged by him in making repairs. Furnish and pay for all instruments necessary for testing. Submit written copies of all test results. Contractor shall provide all materials, labor and retesting necessary to remedy any deficiencies.

B. All testing and corrections shall be made prior to demonstration operation to the Architect, Engineer, and Owner.

C. Demonstrations Tests: Show by demonstration in service that all circuits and devices operate in accordance with manufacturer's specifications. Test the operation of each item of control equipment not less than five times. Submit the request for inspections and tests at least two (2) working days prior to date inspections and tests are to take place.

D. Tests and adjustments shall be made prior to acceptance of the electrical installation by the Architect, and a certificate of inspection and acceptance of the electrical installation by local inspection authorities shall be provided.

E. All equipment or wiring provided, which tests prove to be defective or operating improperly, shall be corrected or replaced promptly, at no additional cost to the Owner.

F. Retesting: Rectify any deficiencies found and retest work affected by such deficiencies.

3.7 INSPECTIONS:

A. All work shall be inspected prior to covering and any work covered prior to inspection will be uncovered and made available for inspection at the option of the Architect/Engineer and/or Owner. The Contractor shall coordinate inspections in advance with the Architect/Engineer and/or Owner. No additional fees shall be provided to uncover and recover any work covered prior to inspection.

END OF SECTION 260050

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 260519 - CABLES, LOW VOLTAGE (600 VOLTS AND BELOW)

PART 1 GENERAL

1.1 DESCRIPTION:

A. This section includes the furnishing, installation, and connection of the low voltage power and lighting wiring. The terms cable, wire and feeder are used interchangeably.

B. Unless otherwise specified in other sections of these specifications, control wiring shall be provided, installed, and connected to perform the functions specified in other sections of these specifications.

C. Unless otherwise specified in other sections of these specifications, communication and signal wiring shall be provided, installed, and connected to perform the functions specified in other sections of these specifications.

1.2 RELATED WORK:

A. Section 260050, BASIC ELECTRICAL METHODS AND REQUIREMENTS

B. Section 260533, CONDUIT SYSTEMS

C. Section 260526, GROUNDING

1.3 SUBMITTALS:

A. Shop Drawings:

1. Submit catalog cuts and descriptive literature for approval as specified herein.
2. Include sufficient information, clearly presented, to determine compliance with drawings and specifications.
3. The specific item(s) proposed shall be marked on the catalog cuts.

1.4 APPLICABLE PUBLICATIONS: The following specifications and standards, except as hereinafter modified, are incorporated herein by reference and form a part of this specification to the extent indicated by the references thereto. Except where a specific date is given, the issue in effect (including amendments, addenda, revisions, supplements, and errata) on the date of Invitation for Bids shall be applicable. In text such specifications and standards are referred to by basic designation only.

A. National Fire Protection Association (NFPA) Publications:

No. 70 ..... National Electrical Code (NEC)

B. Underwriter's Laboratories, Inc. (UL) Publications:

No. 44 ..... Rubber-Insulated Wire and Cables

No. 83 ..... Thermoplastic-Insulated Wires

No. 493 ..... Thermoplastic-Insulated Underground Feeder and Branch Circuit Cables

No. 486 ..... Wire Connectors and Soldering Lugs

PART 2 PRODUCTS

2.1 MATERIALS:

A. Cable and Wire (Power and Lighting):

1. Cable and wire shall be in accordance with UL, NEC, as shown on the drawings, and as hereinafter specified.
2. Conductors:

   a. Shall be single conductor annealed copper, sized not less than shown.
   b. Shall be stranded for all sizes No. 10 and larger. Sizes No. 12 and smaller shall be solid, except control wires and motor feeders.
   c. Minimum size shall be No. 12 AWG, except control wires and fire alarm wiring may be No. 14 AWG.

3. Exposed Conductors: Type XHHW-2.
4. Conductors concealed in ceilings, walls, partitions and crawlspaces: Type THHN-THWN-2
5. Conductors located outdoors, on roofs, underground or wet locations: Type XHHW-2.
6. Where conductors are subject to extreme heat: Type XHHW-2.
7. Color Code:

   a. All secondary service, feeder, and branch circuit conductors shall be color coded as follows:

208/120 Volt	Phase	480/277 Volt
Black	A	Brown
Red	B	Orange
Blue	C	Yellow
White	Neutral	Gray *
Green	Ground	Green

   * or white with Gray stripe

   Control wires shall be violet or purple.

   b. All secondary, service, ungrounded feeder and branch circuit conductors, and equipment grounding conductors larger than #8 (larger than #6 for neutrals) shall be identified with multiple rings or spirals of color coding tape at each box, enclosure, splice, or termination.
   c. All secondary, service, ungrounded feeder and branch circuit conductors, and equipment grounding conductors #8 and smaller shall have continuous solid color insulation. All grounded feeder and branch circuit conductors (neutrals) #6 and smaller shall have continuous solid color insulation.

B. Splices and Joints:

1. Shall be in accordance with UL and NEC.
2. Conductors No. 6 and smaller:

    a. Connectors shall be solderless, screw-on, pressure cable type, 600V-rated, 90 degree C, with integral insulation. They shall be approved for copper conductors, and shall be reusable.
    b. The integral insulator shall have a skirt to completely cover the stripped wires.
    c. The number, size, and combination of conductors, as listed on the manufacturers packaging shall be strictly complied with.
    d. All wires shall be twisted together before installing screw-on connectors.

3. Conductors No. 4 AWG and larger:

    a. Connectors shall be compression type. Material shall be high conductivity copper. Compression connectors shall be applied with special tool sized appropriately for the conductor size, and tool shall not release until full compression is achieved.
    b. Connectors for cable sizes 250 MCM and larger shall have not less than two clamping elements or compression indents per conductor. Connectors for cable sizes smaller than 250 MCM may have one clamping element or compression indent per conductor.

4. Underground conductors:

    a. Connectors for all phase, neutral, and equipment grounding conductors shall be inline or multiport 600V compression connectors which are UL-listed for direct-burial applications.

C. Splice and Joint Insulation:

1. Splices and joints shall be insulated with materials approved for the particular use, location, voltage, and temperature. Insulation level shall be not less than that of the conductors being joined.
2. Plastic Electrical Insulating Tape: Shall be flame retardant, cold and weather resistant, Scotch 33+, or equal.

D. Control Wiring:

1. Unless otherwise specified in other sections of these specifications, control wiring shall be as specified minimum size shall be No. 14 AWG stranded copper.
2. Coordinate with controls manufacturer for exact cable size, type.
3. Wire size shall be large enough so that the voltage drop under inrush conditions will not adversely affect operation of the controls.

E. Wire Lubricating Compounds:

1. Shall be suitable for the wire insulation and conduit it is used with, and shall not harden or become adhesive.

PART 3 EXECUTION

3.1 INSTALLATION, GENERALLY:

A. Installation shall be in accordance with the NEC, as shown on the drawings, and as hereinafter specified.

B. Install all wiring in raceway systems.

C. No more than three circuits shall be pulled into one conduit, except as shown on plans.

D. Splice cables and wires only in outlet boxes, junction boxes, or pull boxes.

E. For panelboards, cabinets, wireways, switches, and equipment assemblies, neatly form, train, and tie the cables in individual circuits.

F. Seal cable and wire entering underground between the wire and conduit, where the cable exits the conduit, with a nonhardening approved compound.

G. Wire Pulling:

1. Provide suitable installation equipment to prevent cutting or abrasion of insulation during pulling of wire. Wiring pulling tensions shall not exceed manufacturer limits. Wire pulling shall not result in damage to conduit systems.
2. Ropes used for pulling feeders shall be made of suitable nonmetallic material.
3. Attach pulling lines for feeders by means of either woven basket grips or pulling eyes attached directly to the conductors.
4. All cables in a single conduit shall be pulled in together.
5. All cables shall be pulled in from reels. Cables shall not be strung out on the surface prior to pulling.

3.2 CONTROL, COMMUNICATION AND SIGNAL SYSTEM IDENTIFICATION:

A. Install a permanent wire marker on each wire at each termination.

B. Identifying numbers and letters on the wire markers shall correspond to those on the wiring diagrams used for installing the systems.

C. Wire markers shall retain their markings after cleaning.

3.3 CIRCUIT AND FEEDER IDENTIFICATION:

A. In each pullbox and junction box, install non-metallic tags, marked with indelible ink, on each cable and wire to clearly designate their circuit identification and voltage. Attach tags with plastic tie wraps.

3.4 FIELD TESTING:

A. All conductors shall be insulation-resistance tested ("megger" test) and current leakage tested. The Contractor shall furnish the instruments, materials and labor for these tests.

B. Insulation-Resistance Test: Test all conductors phase-to-phase and phase-to-ground. Voltage shall be 1000 VDC for insulation rated for 600V. Minimum recorded resistance shall be 100 megohms. Wire and splices not meeting this requirement shall be repaired or replaced and retested until the requirement is met.

C. Current Leakage Test: Energize conductors and test as a complete circuit, except for equipment grounding conductors, using a clamp-on current leakage test device. Maximum recorded leakage current shall be less than 6mA. Wire and splices not meeting this requirement shall be repaired or replaced and retested until the requirement is met.

D. The Contractor shall present to the Architect/Engineer three copies of all test reports and shall include one copy in each maintenance manual. Test reports shall include date, time, and temperature in addition to megger and leakage current readings and identification of circuits or feeders tested.

E. Tests shall be made in the presence of the Owner's Representative, at Owner's option. Notify Owner minimum 48 hours in advance of testing.

END OF SECTION 260519

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 260526 - GROUNDING

PART 1 GENERAL

1.1 DESCRIPTION:

A. System Grounding:

1. Secondary service neutrals shall be grounded at the supply side of the secondary disconnecting means and at the related transformers.

B. Equipment Grounding: All metallic structures, enclosures, raceways, junction boxes, outlet boxes, cabinets, machine frames, and other conductive items in close proximity with electrical circuits shall be grounded for personnel safety and to provide a low impedance path for possible ground fault currents.

1.2 RELATED WORK:

A. Section 260050, BASIC ELECTRICAL METHODS AND REQUIREMENTS

B. Section 260533, CONDUIT SYSTEMS

C. Section 260519, CABLES, LOW VOLTAGE (600 VOLTS AND BELOW)

1.3 SUBMITTALS:

A. Shop Drawings:

1. Submit catalog cuts and descriptive literature for approval as specified herein.
2. Include sufficient information, clearly presented, to determine compliance with drawings and specifications.

1.4 APPLICABLE PUBLICATIONS: The following specifications and standards, except as hereinafter modified, are incorporated herein by reference and form a part of this specification to the extent indicated by the references thereto. Except where a specific date is given, the issue in effect (including amendments, addenda, revisions, supplements, and errata) on the date of Invitation for Bids shall be applicable. In text such specifications and standards are referred to by basic designation only.

A. National Fire Protection Association (NFPA) Publications:

No. 70..... National Electrical Code (NEC)

B. Underwriters Laboratories, Inc. (UL) Publications:

No. 83..... Thermoplastic-Insulated Wires

No. 44..... Rubber-Insulated Wires and Cables

No. 467..... Electrical Grounding and Bonding Equipment

PART 2 PRODUCTS

2.1 GROUNDING WIRES:

A. Shall be bare stranded copper, except that sizes No. 10 AWG and smaller may be solid. Equipment grounding conductors shall be insulated. The requirements of Section 260519, CABLES, LOW VOLTAGE (600 VOLTS AND BELOW) shall apply.

B. Wire size shall not be less than shown on the drawings and not less than required by the NEC.

2.2 GROUND RODS:

A. Ground rods shall be copper-clad steel, sizes as shown on drawings.

PART 3 EXECUTION

3.1 INSTALLATION, GENERALLY:

A. Grounding shall be in accordance with the NEC, as shown on the drawings, and as hereinafter specified.

3.2 EQUIPMENT AND CIRCUITS:

A. Conduit Systems:

1. All line voltage conduit systems, metallic and non-metallic, shall contain a grounding conductor.
2. Conduit provided for mechanical protection and containing only a grounding conductor shall be bonded to that conductor at the entrance and exit from the conduit.
3. Conduit that runs to or from boxes, cabinets or enclosures having concentric knockouts which have not been removed at the conduit connection, shall be provided with bonding jumpers sized in accordance with NEC Table 250.122, and connected with a grounding type bushing / locknut on the conduit and a ground bus or stud inside the box.

B. Feeders and Branch Circuits: Install insulated green grounding conductors with all feeders and branch circuits.

C. Boxes, Cabinets, Enclosures and Panelboards:

1. Bond the grounding wires to each pullbox, junction box, outlet box, cabinets, and other enclosures through which the ground wires pass.
2. Provide lugs in each box and enclosure for ground wire termination.

D. Electrical Appliances and Equipment: Fixed electrical appliances and equipment shall have a ground lug installed for termination of the ground conductor.

3.3 FIELD TESTING:

A. Test the ground resistance of each grounding electrode conductor. The Contractor shall furnish the instruments, materials and labor for these tests.

B. After installation, test all grounding electrode conductors for services and separately derived systems, and all pole-base ufer ground conductors. A clamp-on ground resistance meter shall be used for these tests.

C. The Contractor shall present to the Architect/Engineer three copies of all test reports and shall include one copy in each maintenance manual. Test reports shall include date, time, and temperature in addition to megger and leakage current readings and identification of circuits or feeders.

D. Tests shall be made in the presence of the Owner's Representative, at Owner's option. Notify Owner minimum 48 hours in advance of testing.

END OF SECTION 260526

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Hangers and supports for electrical and telecommunications equipment and systems.
2. Construction requirements for concrete bases.

1.3 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. IMC: Intermediate metal conduit.

C. RMC: Rigid metal conduit.

1.4 ACTION SUBMITTALS

A. Product Data: For the following:

1. Steel slotted support systems.
2. Nonmetallic slotted support systems.

1.5 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Comply with NFPA 70.

1.6 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified together with concrete Specifications.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 077200 "Roof Accessories."

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Allied Tube & Conduit.
b. Cooper B-Line, Inc.; a division of Cooper Industries.
c. ERICO International Corporation.
d. GS Metals Corp.
e. Thomas & Betts Corporation.
f. Unistrut; Tyco International, Ltd.
g. Wesanco, Inc.

2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
3. Dimensions:

a. General Use: 1-5/8" x 1-5/8", equivalent to Unistrut P1000.
b. For supporting conduits and cable tray under raised floors: 13/16" x 13/32", equivalent to Unistrut P7000.

B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

C. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.

E. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

F. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.

a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1) Cooper B-Line, Inc.; a division of Cooper Industries.
2) Empire Tool and Manufacturing Co., Inc.
3) Hilti Inc.
4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
5) MKT Fastening, LLC.

2. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
3. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
4. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
5. Toggle Bolts: All-steel springhead type.
6. Hanger Rods: Threaded steel.
7. Conduit straps: single-hole, Mineralac MED or approved equivalent.

2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Section 055000, "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter..

B. Minimum Hanger Rod Size for Raceway: Minimum rod size shall be 1/4 inch in diameter for supports carrying 1.5 inches conduit(s) or smaller, and 3/8 inches for supports carrying conduit(s)s 2 inches and larger.

C. Multiple Raceways or Cables: Install trapeze-type supports, maximum width 12", fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with two-bolt conduit clamps.

D. 18 gauge galvanized tie wire may be used inside metal stud walls.

E. Conduits above suspended ceilings shall be supported independently of wire supports for ceilings. Caddy 812MB18A box and conduit supports may be used, suspended from threaded rod.

F. Spring steel, powder-actuated, and plastic and lead expansion anchors shall not be used.

3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.

B. Raceway Support Methods: In addition to methods described in NECA 1, EMT, IMC, and RMC may be supported by openings through structure members, as permitted in NFPA 70.

C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To New Concrete: Bolt to concrete inserts.
2. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
3. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts
4. To Light Steel: Sheet metal screws.
5. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Section 055000, "Metal Fabrications" for site-fabricated metal supports.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 CONCRETE BASES

A. Construct concrete bases of dimensions indicated but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

B. Use 3000-psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Section 033000, "Cast-in-Place Concrete."

C. Anchor equipment to concrete base.

1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.5 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 260529

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 260533 - CONDUIT SYSTEMS

PART 1 GENERAL

1.1 DESCRIPTION:

A. This section includes the furnishing, installation, and connection of conduit, fittings, boxes, and supports to form complete, coordinated, grounded raceway systems. Raceway is required for all wiring unless specifically indicated or specified otherwise.

B. Definitions: The term conduit, as used in this specification, shall mean any or all of the raceway types specified.

1.2 RELATED WORK:

A. Section 260050, BASIC ELECTRICAL METHODS AND REQUIREMENTS

B. Section 260526, GROUNDING

1.3 REFERENCES:

A. National Fire Protection Association (NFPA):

70-02 ..... National Electrical Code (NEC)

B. Underwriters Laboratories, Inc. (UL):

1-93 ..... Flexible Metal Conduit
5-96 ..... Surface Metal Raceway and Fittings
6-97 ..... Rigid Metal Conduit
50-95 ..... Enclosures for Electrical Equipment
360 ..... Liquidtight Flexible Steel Conduit
467-93 ..... Grounding and Bonding Equipment
514A-96..... Metallic Outlet Boxes
514B-97 ..... Fittings for Cable and Conduit
651-95 ..... Schedule 40 and 80 Rigid PVC Conduit
651A-95..... Type EB and A Rigid PVC Conduit and HDPE Conduit
797-93 ..... Electrical Metallic Tubing
1242-96 ..... Intermediate Metal Conduit

C. NECA …… Standard of Installation.

D. NEMA:

FB 1	Fittings and Supports for Conduit and Cable Assemblies.
OS 1	Sheet-steel Outlet Boxes, Device Boxes, Covers, and Box Supports.
OS 2	Nonmetallic Outlet Boxes, Device Boxes, Covers and Box Supports.
250	Enclosures for Electrical Equipment (1000 Volts Maximum).

1.4 SUBMITTALS:

A. Provide submittals for all raceways, components, and accessories.

B. Product Data:

1. Submit catalog cuts and descriptive literature for approval as specified herein.
2. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
3. The specific item(s) proposed shall be marked on the catalog cuts.

PART 2 PRODUCTS

2.1 CONDUIT:

A. All conduit and fittings shall be UL listed, in accordance with the NEC, and as hereinafter specified.

B. Size: Minimum size of conduit shall be 3/4 inch, except as otherwise specified or noted on the drawings.

C. Conduit:

1. Galvanized Rigid Steel (RGS) conduit shall be hot dip galvanized and shall comply with ANSI C80.1.
2. Electrical Metallic Tubing (EMT) shall be hot dipped galvanized and shall comply with ANSI C80.3. The maximum size of EMT shall be 2" unless otherwise indicated on drawings.
3. Rigid Non-metallic Conduit (PVC) shall be extruded virgin polyvinyl chloride conforming to NEMA Standard TC-2, and UL 651 and 651A. Conduit shall be Schedule 40 unless otherwise specified herein, or Schedule 80 where specified.

2.2 CONDUIT FITTINGS:

A. Rigid Steel Conduit:

1. Fittings shall be standard one-piece threaded couplings, locknuts, bushings, and elbows. Material shall be electro-galvanized steel, except that locknuts and bushings over 2-inches shall be electro-galvanized malleable iron.
2. Locknuts shall be of the bonding type with sharp edges for digging into the metal wall of an enclosure.
3. Bushings shall be of the metallic insulating type. Grounding bushings shall be locking type and shall be provided with a feed-through compression lug.

4. Thread compound shall ensure ground continuity through the conduits.
5. The following materials are not acceptable: setscrew fittings, fittings made entirely of metal or nonmetallic material.
6. The following materials may be used only as specifically approved for each use by the Owner's Representative: threadless connectors or couplings, split couplings that bolt together, self-threading fittings, and couplings permanently attached to conduit. .

B. Electrical Metallic Tubing Fittings:

1. Material shall be steel only.
2. Couplings and connectors shall be of the liquidtight compression type or setscrew type. Connectors shall have insulated throats.
3. The following materials are not acceptable: setscrew or indent type fittings, die-cast or pressure-cast zinc-alloy fittings, and fittings made of "pot metal".

C. Rigid non-metallic conduit fittings:

1. Fittings shall be solvent-weld type, except for connections to metal boxes and metal conduit for which threaded adapters shall be provided.

D. Condulet Fittings for Rigid Steel Conduit, EMT:

1. Condulets shall be gray iron or malleable iron. Condulets used in damp or wet locations shall be NEMA 3R.
2. Condulets shall not be used for splices.

2.3 BOXES:

A. General:

1. All boxes shall be of the proper size to accommodate the quantity of conductors enclosed in the box, plus 30% spare volume above that required by the NEC for all devices and wires. Use properly sized boxes; the use of extension rings is discouraged.
2. Where 120 volt and 277 volt power are to be located in the same box, install partitions to separate the systems.

B. Device Boxes:

1. Shall be one-piece, hot-dipped galvanized stamped steel with factory-made 1/2" and 3/4" knockout openings on all sides. Gangable boxes or handy boxes shall not be used unless noted in the drawings.
2. Device boxes shall not be less than 4" square and 1-1/2" deep unless otherwise noted. Deep (2-1/8") boxes shall be used where specified herein.
3. Boxes on exterior surfaces, or where exposed to damage, or in wet or damp locations shall be corrosion-resistant cast malleable iron. Boxes shall have threaded hubs and be equipped with neoprene gaskets for their covers.

C. Pull and Junction Boxes Less Than 6"x6":

1. Provide one piece steel covers for surface mounted boxes.
2. Boxes with unused punched out openings shall have the openings filled with factory-made steel knockout plugs.

3. Minimum size 4 11/16" square x 2 1/8" with ½" and ¾ " knockouts on each side, for conduits 1" and larger use boxes 6 x CS (conduit size) X 8 x CS, x 4" minimum.
4. Mount boxes at heights at 48" to top of switches, 16" to top of receptacles. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to top of box unless otherwise indicated.
5. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between boxes and cover plate or supported equipment and box.

D. Pull and Junction Boxes 6"x6" and Larger:

1. Shall be substantially made code-gauge boxes with screw covers. Boxes shall be rigid under torsional and deflecting forces and shall be provided with angle iron framing where required.
2. Covers for surface mounted boxes shall line up evenly with the edges of the boxes. Covers for flush mounted boxes shall extend 3/4" beyond the edge of the box on all sides.

E. Cast Metal Boxes for Damp and Wet Locations:

1. Type FD, cast feralloy, with threaded hubs, cast lugs, neoprene-gasketed cover, and stainless steel screws.

F. Wall Plates:

1. As specified in Section 262726.

G. Cabinets:

1. Provide cabinets as shown on drawings. Contractor to provide the cabinet size as required based on the equipment that will be installed inside.
2. Backboard: provide interior metal panel for mounting terminal blocks and electrical components as per drawing; finish with white enamel.
3. Provide metal barriers to form separate compartments wiring of different systems and voltages.
4. Provide accessory feet for free-standing equipment.

2.4 TERMINAL BLOCKS:

A. Terminals shall comply with NEMA ICS 4 and be UL listed.

B. Power terminals shall be aluminum or copper unit-construction type with closed back and tubular pressure screw connectors, suitable for aluminum or copper conductors, rated 600 volts and 90 degrees C, with clear plastic protective cover. Terminal blocks shall be suitable for locking to adjacent blocks. Ground terminals shall be UL-recognized for grounding and bonding.

C. Signal and control terminals shall be modular construction type, suitable for channel mounting, with tubular pressure screw connectors, rated 300 volts.

2.5 SUPPORTS:

A. Select sizes and types of anchors, fasteners and supports to carry the loads of equipment, boxes, and conduit, including weight of wire. Safe working load shall not exceed 1/4 of proof test load of devices.

B. Anchors and Fasteners:

1. Concrete Structural Elements or Solid Masonry Walls: Use precast steel concrete inserts (set prior to pouring), or machine-bolt expansion anchors.
2. Concrete: Use self-drilling anchors and expansion anchors.
3. Sheet Metal: Sheet metal screws.
4. No plumber's perforated tape or strap iron shall be used to support horizontal runs of conduit in metal stud walls, using an ironworker's tie.

PART 3 EXECUTION

3.1 CONDUIT INSTALLATION:

A. General:

1. Installation shall be in accordance with UL, NEC, as shown on the drawings, and as hereinafter specified. Conduit shall be the size shown, or if not shown, as required by the National Electric Code.
2. No more than 360 cumulative degrees of bends shall be used between pull or junction boxes for power, lighting, or auxiliary systems conduits except as specified herein.
3. Conduits shall be mechanically and electrically continuous, cut square, reamed, deburred, and drawn-up tight. Conduits which are damaged or deformed shall be replaced. Conduit system shall be complete prior to pulling in cables.
4. Install conduit so that condensate or water will not be trapped.
5. Supported within 3' of all changes of direction, within 3' of a connection to an enclosure, and at 8' maximum intervals. Each length of conduit between couplings or connectors shall be supported.
6. Conduit to be routed vertically only in walls to junction boxes above areas with drop ceilings. No horizontal runs through walls are allowed. unless specially approved by Pima County.
6. Vertical conduit runs shall have riser clamps and supports in accordance with the NEC and as shown on the drawings. Supports for cable and wire shall have fittings which include internal wedges and retaining collars.
7. Two-hole pipe straps or individual conduit hangers shall be used for supporting individual conduits.
8. Ends of empty conduit to be closed with plugs or caps at rough-in stage to prevent entry of debris until wires are pulled in.
9. All conduit shall be terminated in a box, cabinet, panel, wireway, or a piece of electrical equipment where the conductors pass through either factory- or field-punch or cut holes. Conduits shall be secured with bonding type locknuts. A plastic bushing shall be provided to protect conductor insulation. Rigid conduit installations shall have two bonding-type locknuts on the inside and an insulated bushing on the outside of the enclosure. EMT installations shall have a conduit connector on the outside and a single grounding locknut on the inside of the enclosure. Conduit connections shall not be made to box covers.
10. Grounding bushings shall be used at either end of a service entrance feeder, at either end of conduits for a multiple-conduit feeder, or where concentric knockouts are used at conduit entries to an enclosure.
11. Field-cut threads shall be coated with a corrosion-inhibiting compound.
12. The following installation methods are prohibited:

    a. Transition from one conduit type to another shall only be made at an approved box or fitting. Types shall not be mixed indiscriminately in the same system.
    b. Reducing washers shall not be used.

B. Concealed Work Installation:

1. In Concrete:

a. Conduit shall be rigid steel used for all bends, offsets, and risers to equipment. Minimum 18" of steel conduit shall be used where risers leave the earth of concrete. Where rigid steel conduits leave the slab, install a threaded coupling for future removal. All steel conduit in concrete shall be half-lap wrapped with 10 mil tape.
b. Conduit shall only be installed in concrete that is 3" thick or greater.
c. Conduit with an outside diameter larger than 1/3 of the slab thickness is not permitted to be installed in the slab.
d. Spacing between conduits in slab shall be approximately six conduit diameters apart except one diameter separation is allowed at conduit crossings.
e. Conduit shall be secured in such a manner as to give maximum clearance from reinforcing steel and finished concrete surface. Minimum clearance to steel or finished concrete is 3/4".
f. Couplings and connections shall be watertight.

C. Exposed Work Installation:

1. Conduit shall be rigid steel. No exceptions per Parks and Recreation.
2. Multiple exposed conduits shall be grouped in neat parallel lines, properly supported.
3. Conduits shall generally not be installed across the floor, but shall cross the structure horizontally and drop vertically to equipment.

D. Underground Conduit Installation:

1. Refer to Section 260543, UNDERGROUND ELECTRICAL CONSTRUCTION.

E. Spare Conduits:

1. Spare conduits shall be installed where shown, and shall be identified at each end with a permanent marker as to where the location of the other end.
2. Spare conduits stubbed up in exposed locations shall be rigid steel with a threaded coupling installed flush with the finished floor. The conduit shall be sealed with threaded pipe plug.
3. All spare conduits shall have a pull string installed, and a plastic bushing provided at each end.

F. Auxiliary Conduit Color Codes:

1. Use the following raceway color for Auxiliary systems:
   a. Black and white - Architectural Use
   b. Red - Fire alarm systems
   c. Blue – Data Communications systems
   d. Yellow – High voltage systems
   e. Orange – Fiber optics systems
   f. Purple – Security systems

G. Wet or Damp Locations:

1. Unless otherwise shown on drawings, conduits shall be rigid steel.

H. Conduits Provided for Protection from Damage:

1. Where wires or cable enter a conduit which is used to provide support or protection from physical damage, a ground bushing with feed-thru lug shall be provided on the end(s) of the conduit to protect the wires or cable from abrasion and to ground the conduit.

3.2 BOX INSTALLATION:

A. Outlets are only approximately located on the plans. Care must be used in the actual location of outlets by consulting the various detailed drawings used by other trades and by securing specific locations from the Architect in the event of a conflict.

B. In addition to boxes shown, install enough pull boxes to prevent damage to cable and wire during pulling and to comply with specified degrees-of-bend limits.

C. All boxes shall be rigidly attached to the structure.

D. Pull and junction boxes shall be installed in an accessible location, and only in unfinished areas. Pull boxes shall only be installed in finished areas by approval of the Architect.

3.3 IDENTIFICATION:

A. Box Covers:

1. Label box covers on the outside to identify panel and circuit numbers, or system contained within the box. Use indelible marker.

END OF SECTION 260533

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Color and legend requirements for raceways, conductors, and warning labels and signs.
2. Labels.
3. Bands and tubes.
4. Tapes and stencils.
5. Tags.
6. Signs.
7. Cable ties.
8. Paint for identification.
9. Fasteners for labels and signs.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples: For each type of label and sign to illustrate composition, size, colors, lettering style, mounting provisions, and graphic features of identification products.

C. Delegated-Design Submittal: For arc-flash hazard study.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply with ASME A13.1 and IEEE C2.

B. Comply with NFPA 70.

C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.

D. Comply with ANSI Z535.4 for safety signs and labels.

E. Comply with NFPA 70E requirements for arc-flash warning labels.

F. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

G. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.

1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

2.2 COLOR AND LEGEND REQUIREMENTS

A. Raceways and Cables Carrying Circuits at 600 V or Less:

1. Black letters on an orange field.
2. Legend: Indicate voltage and system or service type.

B. Color-Coding for Phase and Voltage-Level Identification, 600 V or Less: Use colors listed below for ungrounded service, feeder and branch-circuit conductors.

1. Color shall be factory applied or field applied for sizes larger than No. 8 AWG if authorities having jurisdiction permit.
2. Colors for 208/120-V Circuits:

a. Phase A: Black.
b. Phase B: Red.
c. Phase C: Blue.

3. Colors for 240-V Circuits:

a. Phase A: Black.
b. Phase B: Red.

4. Colors for 480/277-V Circuits:

a. Phase A: Brown.
b. Phase B: Orange.
c. Phase C: Yellow.

5. Color for Neutral: White or gray.
6. Color for Equipment Grounds: Bare copper, green.
7. Colors for Isolated Grounds: Green with white stripe.

C. Warning Label Colors:

1. Identify system voltage with black letters on an orange background.

D. Warning labels and signs shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."

E. Equipment Identification Labels:

1. Black letters on a white field.

2.3 LABELS

A. Vinyl Wraparound Labels: Preprinted, flexible labels laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.

B. Snap-around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameter and that stay in place by gripping action.

C. Self-Adhesive Wraparound Labels: Write-on, 3-mil-thick, vinyl flexible label with acrylic pressure-sensitive adhesive.

1. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating, protective shield over the legend. Labels sized such that the clear shield overlaps the entire printed legend.
2. Marker for Labels: Permanent, waterproof, black ink marker recommended by tag manufacturer.
3. Marker for Labels: Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.

D. Self-Adhesive Labels: Vinyl, thermal, transfer-printed, 3-mil-thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.

1. For arc-flash labels, coordinate with Section 260574 "Overcurrent Protective Device Arc-Flash Study" and with "Identification Schedule" Article.
2. Minimum Nominal Size:

a. 1-1/2 by 6 inches for raceway and conductors.
b. 3-1/2 by 5 inches for equipment.
c. As required by authorities having jurisdiction.

E. Flexible ID tape: Black on clear, ½" for receptacles and switches, 1" for all other equipment. Emergency power: Red letters on clear labels.

2.4 BANDS AND TUBES

A. Snap-around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches long, with diameters sized to suit diameter and that stay in place by gripping action.

B. Heat-Shrink Preprinted Tubes: Flame-retardant polyolefin tubes with machine-printed identification labels, sized to suit diameters of and shrunk to fit firmly around item being identified. Full shrink recovery occurs at a maximum of 200 deg F. Comply with UL 224.

2.5 TAPES AND STENCILS

A. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

B. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mils thick by 1 to 2 inches wide; compounded for outdoor use.

C. Tape and Stencil: 4-inch-wide black stripes on 10-inch centers placed diagonally over orange background and is 12 inches wide. Stop stripes at legends.

D. Floor Marking Tape: 2-inch-wide, 5-mil pressure-sensitive vinyl tape, with yellow and black stripes and clear vinyl overlay.

E. Underground-Line Warning Tape:

1. Tape:

a. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
b. Printing on tape shall be permanent and shall not be damaged by burial operations.
c. Tape material and ink shall be chemically inert and not subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.

2. Color and Printing:

a. Comply with ANSI Z535.1, ANSI Z535.2, ANSI Z535.3, ANSI Z535.4, and ANSI Z535.5.
b. Inscriptions for Red-Colored Tapes: "ELECTRIC LINE, HIGH VOLTAGE"
c. Inscriptions for Orange-Colored Tapes: "TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE"

3. Tag: Type I:

a. Pigmented polyolefin, bright colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
b. Width: 3 inches.
c. Thickness: 4 mils.
d. Weight: 18.5 lb/1000 sq. ft..
e. Tensile according to ASTM D 882: 30 lbf and 2500 psi.

4. Tag: Type ID:

a. Detectable three-layer laminate, consisting of a printed pigmented polyolefin film, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core; bright colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
b. Width: 3 inches.
c. Overall Thickness: 5 mils.
d. Foil Core Thickness: 0.35 mil.
e. Weight: 28 lb/1000 sq. ft..
f. Tensile according to ASTM D 882: 70 lbf and 4600 psi.

F. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 1 inch.

2.6 TAGS

A. Write-on Tags:

1. Polyester Tags: 0.010 inch thick, with corrosion-resistant grommet and cable tie for attachment.

2. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
3. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.7 SIGNS

A. Baked-Enamel Signs:

1. Preprinted aluminum signs, high-intensity reflective, punched or drilled for fasteners, with colors, legend, and size required for application.
2. 1/4-inch grommets in corners for mounting.
3. Nominal Size: 7 by 10 inches.

B. Metal-Backed Butyrate Signs:

1. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs, with 0.0396-inch galvanized-steel backing, punched and drilled for fasteners, and with colors, legend, and size required for application.
2. 1/4-inch grommets in corners for mounting.
3. Nominal Size: 10 by 14 inches.

C. Laminated Acrylic or Melamine Plastic Signs:

1. Engraved legend.
2. Thickness:

a. For signs up to 20 sq. in., minimum 1/16 inch thick.
b. For signs larger than 20 sq. in., 1/8 inch thick.
c. Engraved legend with black letters on white face.
d. Self-adhesive.
e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.8 CABLE TIES

A. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 Deg F according to ASTM D 638: 12,000 psi.
3. Temperature Range: Minus 40 to plus 185 deg F.
4. Color: Black, except where used for color-coding.

B. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 Deg F according to ASTM D 638: 12,000 psi.
3. Temperature Range: Minus 40 to plus 185 deg F.
4. Color: Black.

C. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, and self-locking.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 Deg F according to ASTM D 638: 7000 psi.
3. UL 94 Flame Rating: 94V-0.
4. Temperature Range: Minus 50 to plus 284 deg F.
5. Color: Black.

2.9 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.

B. Install identifying devices before installing acoustical ceilings and similar concealment.

C. Verify identity of each item before installing identification products.

D. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.

E. Apply identification devices to surfaces that require finish after completing finish work.

F. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.

G. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

H. System Identification for Raceways and Cables under 600 V: Identification shall completely encircle cable or conduit. Place identification of two-color markings in contact, side by side.

1. Secure tight to surface of conductor, cable, or raceway.

I. System Identification for Raceways and Cables over 600 V: Identification shall completely encircle cable or conduit. Place adjacent identification of two-color markings in contact, side by side.

1. Secure tight to surface of conductor, cable, or raceway.

J. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.

K. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.

L. Accessible Fittings for Raceways: Identify the covers of each junction and pull box of the following systems with the wiring system legend and system voltage. System legends shall be as follows:

1. "POWER SOURCE and CKT"
2. "EMERGENCY POWER."

M. Vinyl Wraparound Labels:

1. Secure tight to surface at a location with high visibility and accessibility.
2. Attach labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to the location and substrate.

N. Snap-around Labels: Secure tight to surface at a location with high visibility and accessibility.

O. Self-Adhesive Wraparound Labels: Secure tight to surface of raceway or cable at a location with high visibility and accessibility.

P. Self-Adhesive Labels:

1. On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on 1-1/2-inch-high label; where two lines of text are required, use labels 2 inches high.

Q. Snap-around Color-Coding Bands: Secure tight to surface at a location with high visibility and accessibility.

R. Heat-Shrink, Preprinted Tubes: Secure tight to surface at a location with high visibility and accessibility.

S. Marker Tapes: Secure tight to surface at a location with high visibility and accessibility.

T. Self-Adhesive Vinyl Tape: Secure tight to surface at a location with high visibility and accessibility.

1. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding.

U. Tape and Stencil: Comply with requirements in painting Sections for surface preparation and paint application.

V. Floor Marking Tape: Apply stripes to finished surfaces following manufacturer's written instructions.

W. Underground Line Warning Tape:

1. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.
2. Limit use of underground-line warning tape to direct-buried cables.
3. Install underground-line warning tape for direct-buried cables and cables in raceways.

X. Write-on Tags:

1. Place in a location with high visibility and accessibility.
2. Secure using UV-stabilized cable ties.

Y. Baked-Enamel Signs:

1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on minimum 1-1/2-inch-high sign; where two lines of text are required, use signs minimum 2 inches high.

Z. Metal-Backed Butyrate Signs:

1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on minimum 1-1/2-inch-high sign; where two lines of text are required, use signs minimum 2 inches high.

AA. Laminated Acrylic or Melamine Plastic Signs:

1. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on minimum 1-1/2-inch-high sign; where two lines of text are required, use signs minimum 2 inches high.

BB. Cable Ties: General purpose, for attaching tags, except as listed below:

1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

3.2 IDENTIFICATION SCHEDULE

A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.

B. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations of high visibility. Identify by system and circuit designation.

C. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits, More Than 30 A and 120 V to Ground: Identify with self-adhesive raceway labels.

1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.

D. Accessible Fittings for Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive labels containing the wiring system legend and system voltage. System legends shall be as follows:

1. "POWER SOURCE and CKT"
2. "EMERGENCY POWER."

E. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use self-adhesive vinyl tape to identify the phase.

1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.

F. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, use self-adhesive wraparound labels with the conductor or cable designation, origin, and destination.

G. Control-Circuit Conductor Termination Identification: For identification at terminations, provide self-adhesive wraparound labels with the conductor designation.

H. Conductors to Be Extended in the Future: Attach write-on tags to conductors and list source.

I. Auxiliary Electrical Systems Conductor Identification: Self-adhesive vinyl tape that is uniform and consistent with system used by manufacturer for factory-installed connections.

1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.

J. Locations of Underground Lines: Underground-line warning tape for power, lighting, communication, and control wiring and optical-fiber cable.

K. Workspace Indication: Apply floor marking tape or tape and stencil to finished surfaces. Show working clearances in the direction of access to live parts. Workspace shall comply with NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

L. Workspace Clearance Warning: in other than dedicated electrical rooms and hallways install red warning tape on floor. In dedicated electrical rooms and hallways install a label reading:
"WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 42 INCHES (915 MM)."

M. Instructional Signs: Self-adhesive labels, including the color code for grounded and ungrounded conductors.

N. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive equipment labels.

1. Apply to exterior of door, cover, or other access.

2. For equipment with multiple power or control sources, apply to door or cover of equipment, including, but not limited to, the following:

    a. Power-transfer switches.
    b. Controls with external control power connections.

O. Arc Flash Warning Labeling: Self-adhesive labels.

P. Operating Instruction Signs: Self-adhesive labels.

Q. Equipment Identification Labels:

1. Indoor Equipment: Self-adhesive label.
2. Outdoor Equipment: Laminated acrylic or melamine sign.

END OF SECTION 260553

SECTION 260573 - ELECTRICAL SYSTEM PROTECTIVE DEVICE STUDY

PART 1 GENERAL

1.1 DESCRIPTION:

A. The Contractor shall have an arc flash, coordination and fault current study prepared for the electrical overcurrent devices to be installed under this project to assure proper equipment and personnel protection.

B. The study shall present an organized time-current analysis of each protective device in series from the individual device back to the source. The study shall reflect the operation of each device during normal and abnormal current conditions.

C. Submit protective equipment shop drawings simultaneously with or after the protective device study. Equipment submittals will not be approved without the completion and review of the power systems study.

D. If formal completion of studies may cause delay in equipment manufacture, acceptance from Architect may be obtained for preliminary submittal of sufficient study data to ensure that selection of device ratings and characteristics will be satisfactory.

E. Provide for both normal and emergency systems.

F. The arc flash analysis, short circuit and coordination study shall be performed using the latest version of SKM Powertools software.

1.2 SUBMITTALS: In accordance with Section 01300 SUBMITTALS, furnish the following:

A. Submit electronic Powertools files lelectronically via email exchange or download .

B. Closeout documents: Two weeks prior to final inspection, deliver to the Owner four copies of the following certifications and material:

1. Certification by the Contractor that the protective devices have been adjusted and set in accordance with the approved protective device study.
2. Electrical system protective device study, incorporating all changes made during construction, which will reflect as-built conditions and settings of all overcurrent devices.

C. Arc Flash hazard warning labels for all electrical equipment identified on the one line drawings.

1.3 QUALIFICATIONS:

A. The Contractor shall have the coordination study prepared by qualified engineers of the switchgear manufacturer or an approved consultant. The Contractor is responsible for providing all pertinent information required by the preparers to complete the study.

1.4 REQUIREMENTS:

A. The complete study shall include a system one-line diagram and protective coordination plots.

B. One Line Diagram: Show, on the one line diagram, all electrical equipment and wiring to be protected by the existing and new overcurrent devices installed under this project. Clearly show, on the one line, the schematic wiring of the electrical distribution system. Labels shall match those on the construction documents. Each item of equipment shall be labeled with the available fault current as calculated by this study.

C. Short Circuit Study:

1. Perform study in accordance with ANSI C37.5, IEEE Standard 320, and IEEE Standard 141.
2. Include data on power source's short circuit contribution, resistance and reactance component of branch impedances, X/R ratios, base quantities selected and other source impedances.
3. Calculate short circuit momentary duty values and interrupting duty values on the basis of assumed three-phase bolted short circuits at each switchgear bus, switchboard, low voltage motor control center, distribution switchboard, pertinent branch circuit panel and other significant locations through the system. The short circuit tabulations shall include symmetrical fault currents and X/R ratios. For each fault location, list the total duty on the bus, as well as the individual contribution from each connected branch, with its respective X/R ratio.
4. Perform protective device evaluation study to determine adequacy of circuit breakers, molded case switches, automatic transfer switches and fuses by tabulating and comparing short circuit ratings of these devices with calculated fault currents. Apply appropriate multiplying factors based on system X/R ratios and protective device rating standards. Any problem areas or inadequacies in the equipment due to short circuit currents shall be promptly brought to the Architect's attention.

D. Coordination Study:

1. Prepare the coordination curves to determine the required settings of protective devices to assure selective coordination. Graphically illustrate on log-log paper that adequate time separation exists between series devices, including the utility company upstream device. Plot the specific time-current characteristics of each protective device in such a manner that all upstream devices will be clearly depicted on one sheet.
2. The following specific information shall also be shown on the coordination curves:

    a. Device identification.
    b. Voltage and current ratio for curves.
    c. 3-phase and 1-phase ANSI damage points for each transformer.
    d. No-damage, melting, and clearing curves for fuses.
    e. Cable damage curves.
    f. Transformer inrush points.
    g. Maximum short circuit cutoff point.

3. Develop a table to summarize the settings selected for the protective devices. Include in the table the following:

    a. Device identification.
    b. Relay CT ratios, tap, time dial, and instantaneous pickup.
    c. Circuit breaker sensor rating, long-time, short-time, and instantaneous settings, and time bands.
    d. Fuse rating and type.
    e. Ground fault pickup and time delay.

E. Arc Flash Analysis:

1. Perform an arc flash analysis study in accordance with IEEE Std 1584a.
2. Determine the following for each bus analyzed:

    a. Flash Hazard Protection Boundary
    b. Incident Energy Level
    c. Required Personal Protective Equipment Category
    d. Type of Fire Rated Clothing
    e. Limited Approach Boundary
    f. Restricted Approach Boundary
    g. Prohibited Approach Boundary

3. Produce an Arc Flash warning label for each piece of electrical equipment with a specific equipment ID and the previous items listed, as well as the system operating voltage and date of issue. Labels shall be printed in color on adhesive backed nylon labels.
4. Present the data determined by the Arc Flash Analysis Study in a tabular format summary sheet. Include the following for each bus analyzed:

    a. Flash Bus Name
    b. Protective Device Name
    c. Bus Operating Voltage
    d. Bus Bolted Fault Current
    e. Protective Device Bolted Fault Current
    f. Protective Device Arcing Fault Current
    g. Trip/Delay Time (Sec)
    h. Breaker Opening Time (Sec)
    i. Ground
    j. Equipment Type
    k. Gap (mm)
    l. Arc Flash Boundary (in)
    m. Working Distance (in)
    n. Incident Energy (cal/cm^2)
    o. Required Protective FR Clothing Category

1.5 ANALYSIS:

A. Highlight any equipment that is determined to be improperly coordinated or underrated as specified. Provide minor modifications to conform with the study (Examples of minor modifications are trip sizes within the same frame, the time curve characteristics of induction relays, C.T. ranges, etc.).

B. After developing the coordination curves, highlight areas lacking coordination that cannot be coordinated with a minor modification. Present a technical evaluation with a discussion of the logical compromises for best coordination.

1.6 ADJUSTMENTS, SETTINGS AND MODIFICATIONS:

A. Accomplish necessary field settings, adjustments, and minor modification to conform with the study without additional cost to the Owner.

PART 2 PRODUCTS

(NOT USED)

PART 3 EXECUTION

(NOT USED)

END OF SECTION 260573

SECTION 260800 - COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes commissioning process requirements for the following Automatic lighting control systems, assemblies, and equipment:

1. Automatic lighting control system, including light fixtures, UL924 emergency relays, BAS interface..

B. Related Requirements:

1. Section 019113 "General Commissioning Requirements" for general commissioning process requirements and Commissioning Coordinator responsibilities.

1.2 DEFINITIONS

A. BAS: Building automation system.

B. UL: Underwriters Laboratory.

C. HVAC&R: Heating, Ventilating, Air Conditioning, and Refrigeration.

D. "Systems," "Subsystems," "Equipment," and "Components": Where these terms are used together or separately, they shall mean "as-built" systems, subsystems, equipment, and components.

E. CaX; Commissioning Coordinator/Agent

1.3 INFORMATIONAL SUBMITTALS

A. Commissioning Plan:

1. A narrative description of the activities that will be accomplished during each phase of commissioning, including the personnel intended to accomplish each of the activities.
2. A listing of the specific equipment, appliances or systems to be tested and a description of the tests to be performed.
3. Functions to be tested including, but not limited to, calibrations and economizer controls.
4. Conditions under which the test will be performed. Testing shall affirm winter and summer design conditions and full outside air conditions.
5. Measurable criteria for performance.

B. Preliminary Commissioning Report

1. Completed IECC-2018 Commissioning Compliance Checklist
2. Itemization of deficiencies found during testing required by this section that have not been corrected at the time of report preparation.
3. Identification of deferred tests that cannot be performed at the time of report preparation because of project conditions.

4. Project conditions required for performance of the deferred tests.
5. Results of functional performance tests.
6. Functional performance test procedures used during the commissioning process, including measurable criteria for test acceptance.

C. Final Commissioning Report

1. Results of functional performance tests.
2. Disposition of deficiencies found during testing, including details of corrective measures used or proposed.
3. Functional performance test procedures used during the commissioning process including measurable criteria for test acceptance, provided herein for repeatability.
4. Identification of deferred tests that could not be performed due to project conditions
5. Project conditions required for performance of the deferred tests.
6. Final versions of any additional data provided in the Preliminary Commissioning Report.

1.4 QUALITY ASSURANCE

A. Commissioning shall be provided by an Approved Agency as defined in IECC-2018 and approved by the code official.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 GENERAL TESTING REQUIREMENTS

A. Certify that Automatic lighting control system, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents and approved Shop Drawings and submittals.

B. Certify that Automatic lighting devices and control systems have been completed and calibrated, that they are operating according to the Contract Documents and approved Shop Drawings and submittals, and that pretest set points have been recorded.

C. Set systems, subsystems, and equipment into operating mode to be tested according to approved test procedures (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

D. Perform tests using design conditions, whenever possible.

1. Simulated conditions may, with approval of Architect, be imposed using an artificial load when it is impractical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by Commissioning Coordinator and document simulated conditions and methods of simulation. After tests, return configurations and settings to normal operating conditions.
2. Commissioning test procedures may direct that set points be altered when simulating conditions is impractical.
3. Commissioning test procedures may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are impractical.

E. If tests cannot be completed because of a deficiency outside the scope of the Automatic lighting control system, document the deficiency and report it to Owner. After deficiencies are resolved, reschedule tests.

F. Coordinate schedule with, and perform the following activities at the direction of, Commissioning Coordinator.

G. Comply with construction checklist requirements, including material verification, installation checks, start-up, and performance tests requirements specified in Sections specifying Automatic lighting control systemand equipment.

H. Provide technicians, instrumentation, tools, and equipment to complete and document the following:

1. Performance tests.
2. Demonstration of a sample of performance tests.
3. Commissioning tests.
4. Commissioning test demonstrations.

3.2 OCCUPANT SENSOR CONTROLS COMMISSIONING TESTS

A. Occupant sensor controls. Where occupant sensor controls are provided, the following procedures shall be performed:

1. Certify that the occupant sensor has been located and aimed in accordance with manufacturer recommendations.
2. For projects with seven or fewer occupant sensors, each sensor shall be tested.
3. For projects with more than seven occupant sensors, testing shall be done for each unique combination of sensor type and space geometry. Where multiples of each unique combination of sensor type and space geometry are provided, not less than 10 percent and in no case fewer than one, of each combination shall be tested unless the code official or design professional requires a higher percentage to be tested. Where 30 percent or more of the tested controls fail, all remaining identical combinations shall be tested.
4. For occupant sensor controls to be tested, verify the following:
    a. Where occupant sensor controls include status indicators, verify correct operation.
    b. The controlled lights turn off or down to the permitted level within the required time.
    c. For auto-on occupant sensor controls, the lights turn on to the permitted level when an occupant enters the space.
    d. For manual-on occupant sensor controls, the lights turn on only when manually activated.
    e. The lights are not incorrectly turned on by movement in adjacent areas or by HVAC operation.

3.3 TIME-SWITCH CONTROLS COMMISSIONING TEST

A. Time-switch controls. Where time-switch controls are provided, the following procedures shall be performed:

1. Confirm that the time-switch control is programmed with accurate weekday, weekend and holiday schedules provided by owner.
2. Provide documentation to the owner of time-switch controls programming including weekday, weekend, holiday schedules, and set-up and preference program settings.

3. Verify the correct time and date in the time switch.
4. Verify that any battery back-up is installed and energized.
5. Verify that the override time limit is set to not more than 2 hours.
6. Simulate occupied condition. Verify and document the following:

    a. All lights can be turned on and off by their respective area control switch.
    b. The switch only operates lighting in the enclosed space in which the switch is
    c. located.

7. Simulate unoccupied condition. Verify and document the following:

    a. Nonexempt lighting turns off.
    b. Manual override switch allows only the lights in the enclosed space where the over-ride switch is located to turn on or remain on until the next scheduled shutoff occurs.

8. Additional testing as specified by the registered design professional.

3.4 DAYLIGHTING CONTROLS COMMISSIONING TESTS

A. Daylight responsive controls. Where day-light responsive controls are provided, the following shall be verified Control devices have been properly located, field calibrated and set for accurate set points and threshold light levels.

B. Daylight controlled lighting loads adjust to light level set points in response to available daylight.

C. The calibration adjustment equipment is located for ready access only by authorized personnel.

3.5 UL 924 EMERGENCY RELAY COMMISSIONING TESTS

A. UL 924 emergency relay. Where emergency transfer relays are provided, the following procedures shall be performed:

1. Confirm that emergency relays automatically transfer from normal power source to the emergency source upon loss of normal power.
2. Confirm that emergency lighting controlled by occupancy sensors, dimmers, and/or daylights sensors automatically switch to full output upon loss of power.
3. Confirm that emergency lighting controlled by occupancy sensors, dimmers, and/or daylights sensors automatically switch to full output when fire alarm system is alarm.

END OF SECTION 230800

SECTION 260923 - LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Photoelectric switches.
2. Daylight-Harvesting Dimming Controls
3. Indoor occupancy sensors
4. Switchbox-mounted occupancy sensors
5. Outdoor motion sensors.
6. Emergency Interface Relays

B. Related Requirements:

1. Section 26-27-26 "Wiring Devices" for wall-box dimmers and manual light switches.
2. Section 26-51-19, "LED Interior Lighting"

C. Lighting control devices shall be fully compatible with relay-based lighting controls and light fixtures, ballasts, and/or drivers. The contractor is responsible for coordinating and verifying the compatibility and interoperability of all lighting and lighting control equipment, whether basis of design of substitutions.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Manufacturer shall substantiate conformance to this specification by supplying the necessary documents, performance data and wiring diagrams. Any deviations to this specification must be clearly stated by letter and submitted.

C. Submit lighting and control plans clearly marked by manufacturer showing proper product, location and orientation of each sensor, room controller, power pack, relay, emergency interface relay, and all devices required for complete system operation. Show all interconnecting cabling. Provide control matrix demonstrating the design and control intent shown on the drawings. Provide typical riser diagrams keyed to plan drawings by room numbers.

D. Submit any interconnection diagrams per major subsystem showing proper wiring.

E. Submit standard catalog literature which includes performance specifications indicating compliance to the specification.

F. Catalog sheets must clearly state any load restrictions when used with electronic ballasts.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Power Pack: Furnish two.
2. Room Controller: Furnish two.
3. Emergency Interface Relay: Furnish one.
4. Occupancy Sensors: Furnish two of each type utilized in the project.

PART 2 - PRODUCTS

2.1 OUTDOOR PHOTOELECTRIC SWITCHES

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings by Sensor Switch/nLight.

B. Description: Solid state, with dry contacts rated for 1800 VA, to operate connected load, complying with UL 773.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range.
3. Time Delay: Thirty-second minimum, to prevent false operation.
4. Lightning Arrester: Air-gap type. Surge Protection: Metal-oxide varistor.
5. Mounting: Twist lock complying with NEMA C136.10, with base -and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.
6. Normally closed, fail on.

2.2 DAYLIGHT-HARVESTING SWITCHING AND DIMMING CONTROLS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings by Sensor Switch/nLight.

B. All sensors except those in electrical and utility rooms will be digitally addressable and fully networked with room controller(s) and relay-based lighting controls.

C. System Description: Sensing daylight and electrical lighting levels, the closed-loop system adjusts the indoor electrical lighting levels. As daylight increases, the lights are dimmed or step-dimmed.

1. Lighting control set point is based on two lighting conditions:

a. When no daylight is present (target level).
b. When significant daylight is present.

2. Provide one hand-held, remote-control tools for configuration and adjustment.

D. Ceiling-or wall Mounted Dimming Controls: Solid-state, light-level sensor unit, with separate controller unit, to detect changes in lighting levels that are perceived by the eye.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Sensor Output: 0- to 10-V dc to operate electronic dimming ballasts or LED drivers. Sensor is powered by controller unit.
3. Power Pack: Sensor has 24-V dc, Class 2 power source, as defined by NFPA 70.
4. Light-Level Sensor Set-Point Adjustment Range: 20 to 60 fc (120 to 640 lux).
5. Time Delay: Adjustable from 5 to 300 seconds to prevent cycling.
6. Set-Point Adjustment: Equip with dead-band adjustment of 25, 50, and 75 percent above the "on" set point, or provide with separate adjustable "on" and "off" set points.
7. Test Mode: User selectable, overriding programmed time delay to allow settings check.
8. Control Load Status: User selectable to confirm that load wiring is correct.
9. Indicator: Two digital displays to indicate the beginning of on-off cycles.

2.3 INDOOR OCCUPANCY SENSORS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings by Sensor Switch/nLight.

B. General Requirements for Sensors: Wall- or ceiling-mounted, solid-state indoor occupancy sensors with a separate power pack.

1. All sensors except those in electrical and utility rooms will be digitally addressable and fully networked with room controller(s) and relay-based lighting controls.
2. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Operation: Unless otherwise indicated, manually turn lights on when coverage area is occupied, and automatically turn them off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
4. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor is powered from the power pack.
5. Power Pack: Dry contacts rated for 20-A ballast or LED driver load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.
6. Mounting:

    a. Sensor: Suitable for mounting in any position on a standard outlet box.
    b. Relay: Externally mounted through a 1/2-inch knockout in a standard electrical enclosure.
    c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door or IR receiver.
    d. Sensors mounted at 8 feet or below suitable for high abuse and/or public areas.

7. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.
8. Bypass Switch: Override the "on" function in case of sensor failure.

C. Dual-Technology Type: Ceiling mounted; detect occupants in coverage area using PIR and ultrasonic/microphonics detection methods. The particular technology or combination of technologies that control on-off functions is selectable in the field by operating controls on unit.

1. Sensitivity Adjustment: Separate for each sensing technology.
2. Detector Sensitivity: Detect occurrences of 6-inch- minimum movement of any portion of a human body that presents a target of not less than 36 sq. in., and detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/s.
3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. when mounted on a 96-inch- high ceiling.

2.4 SWITCHBOX-MOUNTED OCCUPANCY SENSORS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings by Sensor Switch/nLight.

B. General Requirements for Sensors: Automatic-wall-switch occupancy sensor, suitable for mounting in a single gang switchbox. All sensors except those in restrooms and utility rooms will be digitally addressable and fully networked with room controller(s) and relay-based lighting controls.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F.
3. Switch Rating: Not less than 800-VA fluorescent/LED at 120 V, 1200-VA fluorescent/LED at 277 V, and 800-W incandescent.

C. Wall-Switch Sensor:

1. Standard Range: 180-degree field of view, field adjustable from 180 to 40 degrees; with a minimum coverage area of [900 sq. ft.]
2. Sensing Technology: Dual technology - PIR and ultrasonic/microphonics.
3. Switch Type: SP, dual circuit., field selectable automatic "on," or manual "on" automatic "off." as indicated on drawings.
4. Voltage: Dual voltage, 120 and 277 V or 24 V as indicated on drawings.
5. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
6. Concealed "off" time-delay selector at 30 seconds, and 5, 10, and 20 minutes.
7. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and helps eliminate false "off" switching.
8. Provide device and wallplate color and material to match toggle switch requirements in Section 262726 “Wiring Devices.”

2.5 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 24 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Network cabling twisted shielded pair or CAT5E, plenum rated as required by manufacturer. Comply with Division 26 and 27.

2.6 NETWORK COMPONENTS

A. Provide all components necessary to network the system. Refer to drawings for typical interconnections.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

B. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting sensors to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

1. For occupancy and motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner's operations. Refer to Lighting Control Sequence of Operations.

C. Wiring Method: Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Identify components and power and control wiring according to Section 260553, "Identification for Electrical Systems."

E. Program all system function, including those that interface with systems.

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections before programming with a factory-authorized service representative:

1. Operational or Pre-functional Test: After installing time switches and sensors, and lighting control system, and after electrical circuitry has been energized, start units to confirm proper unit operation.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Testing Agency: Owner will engage a qualified Commissioning Authority or Agent to evaluate lighting control devices and perform functional tests and inspections after programming by a factory-authorized service representative.

C. Lighting control devices will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.3 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting sensors to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

1. For occupancy and motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner's operations per Sequence of Operations.
2. For daylighting controls, adjust set points and deadband controls to suit Owner's operations per Sequence of Operations.

3.4 COMMISSIONING

A. Refer to Section 019113, "Commissioning General Requirements, and Section 260800, "Electrical Systems Commissioning Requirements."

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices. Commissioning Authority to witness all training.

END OF SECTION 260923

SECTION 260943 - NETWORK LIGHTING CONTROLS

PART 1 - GENERAL

1.1 SUMMARY

A. The specified lighting control system shall provide time-based, sensor-based (both occupancy and daylight), and manual lighting control.

B. The system shall be capable of turning lighting loads on/off as well as dimming lights (if lighting load is capable of being dimmed)

C. System devices shall be networked together enabling digital communication and shall be individually addressable.

D. The system architecture shall be capable of enabling stand-alone groups (rooms) of devices to function in some default capacity even if network connectivity to the greater system is lost.

E. The system architecture shall facilitate remote operation via a computer connection.

F. The system shall not require any centrally hardwired switching equipment.

1.2 DEFINITIONS

A. BAS – Building Automation System.

1.3 SUBMITTALS

A. Product Datasheets (general device descriptions, dimensions, wiring details, nomenclature)

B. Riser Diagrams – system wide (detailed drawings showing device interconnectivity of devices for control and power supply).

C. Other Diagrams – as needed for operation or interaction with other system(s)

D. Contractor Startup/Commissioning Sample Worksheet – must be completed prior to factory start-up

E. Hardware and Software Operation Manuals.

1.4 QUALITY ASSURANCE

A. All steps in sensor manufacturing process shall occur in the USA; including population of electronic components on circuit boards, soldering, programming, wiring, and housing.

B. All components and the manufacturing facility where product was manufactured must be ROHS compliant.

C. All applicable products must be UL / CUL Listed or other acceptable national testing organization.

1.5 COORDINATION

A. Coordinate lighting control components to form an integrated interconnection of compatible components.

B. Coordinate lighting controls with BAS (if necessary) either through IP based intercommunication of system or hardwired auxiliary relay outputs.

C. The Contractor shall be responsible for a complete and functional system in accordance with applicable local and national codes.

1.6 WARRANTY

A. Devices in lighting control system shall have a 5 year warranty.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product by nLight Network Control System (Sensor Switch).:

2.2 SYSTEM REQUIREMENTS

A. System shall have an architecture that is based upon three main concepts; 1) intelligent lighting control devices 2) standalone lighting control zones 3) network backbone for remote or time based operation.

B. Intelligent lighting control devices shall consist of one or more basic lighting control components; occupancy sensors, photocell sensors, relays, dimming outputs, manual switch stations, and manual dimming stations. Combining one or more of these components into a single device enclosure should be permissible so as to minimize overall device count of system.

C. Intelligent lighting control devices shall communicate digitally, require ~2 mA of current to function (Graphic WallPod excluded), and posses at least two RJ-45 connectors.

D. Lighting control zones shall consist of one or more intelligent lighting control components, be capable of stand-alone operation, and be capable of being connected to a higher level network backbone.

E. Devices within a lighting control zone shall be connected with CAT-5 low voltage cabling, in a daisy-chain fashion, and in any order.

F. Lighting control zone shall be capable of automatically configuring itself for default operation without any start-up labor required.

G. Individual lighting zones must continue to provide a user defined default level of lighting control in the event of a system communication failure with the backbone network or the management software becoming unavailable.

H. Power for devices within a lighting control zone shall come from either resident devices already present for switching purposes (relay device), or from the network backbone. Standalone "bus power supplies" shall not be required in all cases.

I. Switching and dimming for a specific lighting zone shall take place within the devices located in the zone itself (i.e. not in a remotely located devices such as panels) to facilitate system robustness and minimize wiring requirements. Specific applications that require centralized or remote switching shall be capable of being accommodated.

J. System shall have a primary wall mounted network control "gateway" device that is capable of accessing and controlling all other system devices and linking into an Ethernet LAN.

K. System shall use "bridge" devices that route communication and distribute power for up to 8 lighting zones together for purposes of decreasing system wiring requirements.

L. System shall have a web-based software management program that enables remote system control, status monitoring, and creation of lighting control profiles.

M. Individual lighting zones shall be capable of being segmented into several channels of occupancy, photocell, and switch functionality for more advanced configurations and sequences of operation.

N. System shall be capable of operating a lighting control zone according to several sequences of operation:

1. Auto-On / Auto-Off (via occupancy sensors)
2. Manual-On / Auto-Off
3. Auto-to-Override On
4. Manual-to-Override On
5. Auto On/Predictive Off
6. Multi-Level On (multiple lighting levels per manual button press)

O. A taskbar style application shall be available for individual lighting control.

P. Control software shall enable logging of system performance data.

Q. Control software shall enable a basic level of integration with a BAS.

2.3 INDIVIDUAL DEVICE SPECIFICATIONS

A. Gateway Control Module (Sensor Switch Model nGWY).

1. Module shall be a wall mounted user accessible device that is capable of communicating and controlling downstream system control devices and linking into an Ethernet.
2. Devices shall be powered by low voltage, fit within a two gang switch box, and have a backlit LCD panel.
3. User control shall be made available via finger-touch buttons with no moving parts. Buttons shall be capable of being locked for security.

4. Device shall have three RJ-45 ports for connection to other backbone devices (bridges) or directly to a lighting control zones devices.
5. Device shall automatically detect all devices downstream of it.
6. Device shall have a standard and astronomical internal time clock.
7. Device shall have one RJ-45 10/100 BaseT Ethernet connection.
8. Each control gateway device shall be capable of linking 400 devices to the management software.
9. Device shall be capable of using a dedicated or DHCP assigned IP address.

B. Network System Occupancy Sensors

1. Occupancy sensors system shall sense the presence of human activity within the desired space using passive infrared (PIR) technology, which detects occupant motion, to initially turn lights "ON" from an "OFF" state; thus preventing false "ON" conditions. Ultrasonic or Microwave based sensing technologies shall not be accepted. Occupancy sensors shall have a second method adequately detect maintained occupancy sensor with an additional "dual" technology.
2. Dual technology sensors shall have one of its two technologies not require motion to detect occupancy. Acceptable dual technology includes PIR/Microphonics (also known as Passive Dual Technology or PDT) which both looks for occupant motion and listens for sounds indicating occupants. Sensors where both technologies detect motion (PIR/Ultrasonic) shall not be acceptable.
3. All sensing technologies shall be acoustically passive meaning they do not transmit sounds waves of any frequency (for example in the Ultrasonic range), as these technologies have the potential for interference with other electronic devices within the space (such as electronic white board readers). Acceptable detection technologies include Passive Infrared (PIR), and/or Microphonics technology. Ultrasonic or Microwave based sensing technologies shall not be accepted.
4. Sensors shall be available with zero, one, or two integrated Class 1 switching relays, and up to one 0-10 VDC dimming output. Senors shall be capable of switching 120 / 277 / 347 VAC. Load ratings shall be 800 W @ 120 VAC, 1200 W @ 277 VAC, 1500 W @ 347 VAC, and ¼ HP motor. Relays shall be dry contacts.
5. Sensors shall be available with one or two occupancy "poles", each of which provides a programmable time delay.
6. Sensors shall be available in multiple lens options which are customized for specific applications.
7. Communication and Class 2 low voltage power shall be delivered to each device via standard CAT-5 low voltage cabling with RJ-45 connectors.
8. All sensors shall have two RJ-45 ports.
9. Every sensor parameter shall be available and configurable remotely from the software and locally via the device push-button.
10. Sensors shall be able to function together with other sensors in order to provide expanded coverage areas by simply daisy-chain wiring together the units with CAT-5 cabling.
11. Sensors shall be equipped with an automatic override for 100 hour burn-in of lamps. This feature must be available at any time for lamp replacements.
12. Wall switch sensors shall recess into a single-gang switch box and fit a standard Decora style coverplate.
13. Wall switch sensors must meet NEC grounding requirements by providing a dedicated ground connection and grounding to mounting strap. Line and load wire connections shall be interchangeable. Sensor shall not allow current to pass to the load when sensor is in the unoccupied (Off) condition.
14. Wall switch sensors shall have optional features for photocell/daylight override, vandal resistant lens, and low temperature/high humidity operation.

15. Wall switch sensors shall be available in four standard colors, ivory with wall plate per Specification Section 262726.
16. Wall switch sensors shall be the following Sensor Switch model numbers, with device color and optional features as specified on drawings.
17. Network system shall also have ceiling, fixture, recessed, & corner mounted sensors available.
18. Sensors shall have optional features for photocell/daylight override, dimming control, and low temperature/high humidity operation.
19. Sensors with dimming can control 0 to 10 VDC dimmable ballasts by sinking up to 20 mA of Class 2 current (typically 40 or more ballasts).
20. Sensors shall be the following Sensor Switch model numbers, with device options as specified:

C. Networked Power (Relay) Packs

1. Power Pack shall incorporate one or more Class 1 relays and contribute low voltage power to the rest of the system. Slave Packs shall incorporate the relay(s), shall have an optional 2nd relay or 0-10 VDC dimming output, but shall not be required to contribute system power. Power Supplies shall provide system power only, but are not required to switch line voltage circuit. Auxiliary Relay Packs shall switch low voltage circuits only.
2. Power Packs shall accept 120 or 277 VAC (or optionally 347 VAC), be plenum rated, and provide Class 2 power to the system.
3. All devices shall have two RJ-45 ports.
4. Every Power Pack parameter shall be available and configurable remotely from the software and locally via the device push-button.
5. Power Pack shall securely mount to junction location through a threaded ½ inch chase nipple. Plastic clips into junction box shall not be accepted. All Class 1 wiring shall pass through chase nipple into adjacent junction box without any exposure of wire leads. Note: UL Listing under Energy Management or Industrial Control Equipment automatically meets this requirement, whereas Appliance Control Listing does not meet this safety requirement.
6. When required by local code, Power Pack must install inside standard electrical enclosure and provide UL recognized support to junction box. All Class 1 wiring is to pass through chase nipple into adjacent junction box without any exposure of wire leads.
7. Class 1 Relays used in Power (Slave) Packs shall provide 16 Amp switching of all load types, and be rated for 400,000 cycles.
8. Power (Relay) Packs and Supplies shall be the following Sensor Switch model numbers:

    a. nPP16 (Power Pack w/ relay)
    b. nSP16 (Slave Pack w/ relay)
    c. nSP5 2P (Slave Pack w/ two relays)
    d. nPS 80 (Power Supply)
    e. nAR 40 (Low voltage auxiliary relay pack)
    f. nPP16 ER (Emergency relay pack)

D. Wall Switches & Dimmers

1. Devices shall recess into a single-gang switch box and fit a standard Decora style coverplate.
2. Devices shall be available with zero or one integrated Class 1 switching relay.
3. Communication and Class 2 low voltage power shall be delivered to each device via standard CAT-5 low voltage cabling with RJ-45 connectors.
4. All sensors shall have two RJ-45 ports.
5. All devices shall provide toggle switch control. Dimming control and low temperature/high humidity operation are available options.
6. Devices shall be available in four colors, ivory with wall plates per Specification Section 262726.

7. Devices with dimming control outputs can control 0 to 10 VDC dimmable ballasts by sinking up to 20 mA of Class 2 current (typically 40 or more ballasts).
8. Provide device and wallplate color and material to match toggle switch requirements in Section 262726 "Wiring Devices."
9. Wall switches & dimmers shall be the following Sensor Switch model numbers, with device options as specified on drawing.

E. Scene Controller

1. Device shall have four buttons for selecting programmable lighting control profiles or acting as on/off switches.
2. Device shall recess into single-gang switch box and fit a standard GFI opening.
3. Device shall provide user control via touch sensitive buttons which have no mechanical parts.
4. Communication and Class 2 low voltage power shall be delivered to each device via standard CAT-5 low voltage cabling with RJ-45 connectors.
5. All sensors shall have two RJ-45 ports.
6. Device shall have four touch sensitive buttons for selecting programmable lighting control profiles.
7. Device shall have four bi-color LEDs indicating current selection.
8. Provide device and wallplate color and material to match toggle switch requirements in Section 262726 "Wiring Devices."
9. Scene Selector device shall be the following Sensor Switch model number as specified on drawings

F. Communication Bridges

1. Device shall surface mount to a standard 4" x 4" square junction box.
2. Device shall have 8 RJ-45 ports.
3. Device shall be capable of aggregating communication from multiple lighting control zones for purposes of minimizing backbone wiring requirements back to Control Gateway.
4. Device shall be powered with Class 2 low voltage supplied locally via a directly wired power supply or delivered via a CAT-5 cabled connection.
5. Device shall be careful of redistributing power from its local supply and connect lighting control zones with excess power to lighting control zones with insufficient local power. This architecture also enables loss of power to a particular area to be less impactful on network lighting control system.
6. Communication Bridge devices shall be the following Sensor Switch model numbers:

    a. nBRG 8 (8 Ports)

G. DAYLIGHT-HARVESTING SWITCHING AND DIMMING CONTROLS

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings by Sensor Switch/nLight.
2. All sensors except those in electrical and utility rooms will be digitally addressable and fully networked with room controller(s) and relay-based lighting controls.
3. System Description: Sensing daylight and electrical lighting levels, the closed-loop system adjusts the indoor electrical lighting levels. As daylight increases, the lights are dimmed or step-dimmed.

    a. Lighting control set point is based on two lighting conditions:

        1) When no daylight is present (target level).
        2) When significant daylight is present.

    b. Provide two hand-held, remote-control tools for configuration and adjustment.

4. Ceiling-or wall Mounted Dimming Controls: Solid-state, light-level sensor unit, with separate controller unit, to detect changes in lighting levels that are perceived by the eye.

    a. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
    b. Sensor Output: 0- to 10-V dc to operate electronic dimming ballasts or LED drivers. Sensor is powered by controller unit.
    c. Power Pack: Sensor has 24-V dc, Class 2 power source, as defined by NFPA 70.
    d. Light-Level Sensor Set-Point Adjustment Range: 20 to 60 fc (120 to 640 lux).
    e. Time Delay: Adjustable from 5 to 300 seconds to prevent cycling.
    f. Set-Point Adjustment: Equip with dead-band adjustment of 25, 50, and 75 percent above the "on" set point, or provide with separate adjustable "on" and "off" set points.
    g. Test Mode: User selectable, overriding programmed time delay to allow settings check.
    h. Control Load Status: User selectable to confirm that load wiring is correct.
    i. Indicator: Two digital displays to indicate the beginning of on-off cycles.

2.4 LIGHTING CONTROL PROFILES

A. Changes to the operation of the system shall be capable of being made in real-time or scheduled via lighting control profiles. These profiles are outlines of settings that direct how a collection of devices function for a defined time period.

B. Lighting control profiles shall be capable of being created and applied to a single device, zone of devices, or customized group of zones.

C. All relays and dimming outputs shall be capable of being scheduled to track or ignore information regarding occupancy, daylight, and local user switches via lighting control profiles.

D. Every device parameter (e.g. sensor time delay and photocell set-point) shall be configurable via a lighting control profile.

E. All lighting control profiles shall be stored on the network control gateway device and on the software's host server.

F. Lighting control profiles shall be capable of being scheduled to run according to the following calendar options: start date/hour/minute, end date/hour/minute, and sunrise/sunset +/- timed offsets.

G. Sunrise/sunset times shall be automatically derived from location information using an astronomical clock.

H. Daylight savings time adjustments shall be capable of being performed automatically, if desired.

I. Lighting control profile schedules shall be capable of being given the following recurrence settings: daily, weekday, weekend, weekly, monthly, and yearly.

J. Software shall provide a graphical tool for easily viewing scheduled lighting control profiles.

2.5 MANAGEMENT SOFTWARE

A. Every device parameter (e.g. sensor time delay and photocell set-point) shall be available and configurable remotely from the software

B. The following status monitoring information shall be made available from the software for all devices for which it is applicable: current occupancy status, current PIR Status, current Microphonics Status, remaining occupancy time delay(s), current photocell reading, current photocell inhibiting state, photocell transitions time remaining, current dim level, device temperature, and device relay state(s).

C. The following device identification information shall be made available from the software: model number, model description, serial number, manufacturing date code, custom label(s), and parent network device.

D. A printable network inventory report shall be available via the software.

E. Software shall require all users to login with a User Name and Password.

F. Software shall provide at least three permission levels for users.

G. All sensitive stored information and privileged communication by the software shall be encrypted.

H. All device firmware and system software updates must be available for automatic download and installation via the internet.

2.6 START-UP FEATURES

A. To facilitate start-up, all devices daisy-chained together (using CAT-5) shall automatically be grouped together into a functional lighting control zone.

B. Lighting control zones shall be able to function according to default settings once adequate power is applied and before any system software is installed.

C. Once software is installed, system shall be able to auto-discover all system devices without requiring any commissioning.

D. System devices shall be capable of being given user defined names.

E. Devices within the network shall be able to have their firmware reprogrammed remotely and without being physically uninstalled for purposes of upgrading functionality at a later date.

2.7 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Class 2 Power Source: Not smaller than No. 12 AWG, complying with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

B. Structured Network Digital and Multiplexed Signal Cables: UTP cable with copper conductors, complying with TIA/EIA-568-B.2, Category 5e for horizontal copper cable.

C. RS-485 Cables:

1. Standard Cable: NFPA 70, Type CM.

   a. Paired, 2 pairs, twisted, No. 22 AWG, stranded (7x30) tinned copper conductors.
   b. PVC insulation.
   c. Unshielded.
   d. PVC jacket.
   e. Flame Resistance: Comply with UL 1581.

2. Plenum-Rated Cable: NFPA 70, Type CMP.

   a. Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors.
   b. Fluorinated ethylene propylene insulation.
   c. Unshielded.
   d. Fluorinated ethylene propylene jacket.
   e. Flame Resistance: NFPA 262, Flame Test.

PART 3 - EXECUTION

3.1 WIRING INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Install wiring in raceways except where installed in accessible ceilings. Minimum conduit size shall be 1/2 inch.

C. For power wiring comply with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables".

D. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Separate power-limited and non-power-limited conductors according to conductor manufacturer's written instructions.

E. Install field-mounting transient voltage suppressors for lighting control devices in Category A locations that do not have integral line-voltage surge protection.

F. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.

G. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in terminal cabinets, equipment enclosures, and in junction, pull, and outlet boxes.

H. Identify components and power and control wiring according to Division 26 Section "Identification for Electrical Systems."

3.2 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections:

1. Test for circuit continuity.
2. Verify that the control module features are operational.
3. Check operation of local override controls.
4. Test system diagnostics by simulating improper operation of several components selected by Architect.

E. Lighting controls will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

3.3 SOFTWARE INSTALLATION

A. Install and program software with initial settings of adjustable values. Make backup copies of software and user-supplied values. Provide current licenses for software.

3.4 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.5 DEMONSTRATION

A. Contractor/Equipment supplier shall train Owner's maintenance personnel to adjust, operate, and maintain lighting controls and software training for PC-based control systems. Provide six (6) hours training and set-up time.

END OF SECTION 260943

SECTION 262416 - PANELBOARDS

PART 1 GENERAL

1.1 DESCRIPTION:

A. This section includes the furnishing, installation and connection of branch circuit and distribution panelboards [and lighting control panelboards. The terms panelboards, distribution panelboards, and lighting control panelboards shall be used interchangeably for components that apply to both].

1.2 RELATED WORK:

A. Section 260050, BASIC ELECTRICAL METHODS AND REQUIREMENTS

B. Section 260533, CONDUIT SYSTEMS

C. Section 261800, OVERCURRENT PROTECTIVE DEVICES

D. Section 260526, GROUNDING

1.3 SUBMITTALS:

A. Provide submittals for all panelboards, components, and accessories per the requirements of Section 01300, SUBMITTALS.

B. Product Data:

1. Submit catalog cuts and descriptive literature for approval as specified herein.
2. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications. Include electrical ratings, dimensions, mounting, material, wiring diagrams, circuit breakers, programming information, and accessories. Submittal shall have material keyed to panelboard designations on plans.
3. The specific item(s) proposed shall be marked on the catalog cuts.

1.4 APPLICABLE PUBLICATIONS: The following specifications and standards, except as hereinafter modified, are incorporated herein by reference, and form a part of this specification to the extent indicated by the references thereto. Except where a specific date is given, the issue in effect (including amendments, addenda, revisions, and supplements, and errata) on the date of Invitation for Bids shall be applicable. In text such specifications and standards are referred by basic designation only.

A. Underwriters Laboratories, Inc. (UL) Publications:

No. 50 ..... Cabinet and Boxes, Electrical

No. 67 ..... Panelboards

No. 489 ..... Molded Case Circuit Breakers and Circuit Breaker Enclosures

B. National Fire Protection Association (NFPA) Publications:

No. 70 ..... National Electrical Code (NEC)

C. National Electrical Manufacturers Association (NEMA) Publications:

No. PB-1 ..... Panelboards

No. AB-1..... Molded Case Circuit Breakers

PART 2 PRODUCTS

2.1 PANELBOARDS:

A. General:

1. Panelboard Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include the following:

    a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
    b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
    c. Siemens Energy & Automation, Inc.
    d. Square D; a brand of Schneider Electric.

3. Panelboards shall be in accordance with UL, NEMA, NEC, and as shown on the drawings.
4. Provide standard manufactured products. All components of panelboards shall be the product and assembly of the same manufacturer. All similar units of all panelboards to be of the same manufacturer.
5. All panelboards shall be dead front safety type. Arrange sections for easy removal without disturbing other sections.
6. All panelboards shall be completely factory assembled with molded case circuit breakers.
7. Panels shall have main breaker or main bus, bus size, voltage, phase, and flush or surface mounting as scheduled on the drawings.
8. Panelboards shall have the following features:

    a. Nonreduced size copper bus bars, and connection straps bolted together and rigidly supported on molded insulators. Bus bar taps for panels with single pole branches shall be arranged for sequence phasing of branch circuit devices.
    b. Full size neutral bar, mounted on insulated supports.
    c. Ground bar with sufficient terminals for all grounding wires. Provide isolated ground bar if shown on drawings.
    d. Buses braced for amperes symmetrical as shown on drawings.
    e. All breakers arranged so that it will be possible to substitute a 2-pole breaker for two single pole breakers, and a 3-pole breaker for three single pole breakers, when frame size is 100 amperes or less.
    f. Design interior so that protective devices can be replaced without removing adjacent units, main bus connectors, and without machine drilling or tapping.
    g. Where designated on panel schedule as "space", include all necessary bussing, device support and connections. Provide blank cover for each space.
    h. Panelboards shall have main circuit breaker or main lugs only as shown. Provide sufficient lugs for main breaker or main lug interiors with space to terminate all conductors shown on plans.
    i. Panelboards shall be a minimum of 20" wide by 5-3/4" deep.

2.2 CABINETS AND TRIMS:

A. Cabinets:

1. Provide galvanized steel cabinets to house panelboards. Cabinets for distribution panels may be factory primed and suitably treated with a corrosion-resisting paint finish meeting UL standard for outdoor applications.
2. Back and sides shall be of one piece formed steel. Cabinets for distribution panels may be of formed sheet steel with end and side panels welded, riveted, or bolted as required.
3. Provide minimum of four interior mounted studs and necessary hardware for "in" and "out" adjustment of panel interior.
4. Cabinets for two section panelboards shall have both sections bolted together, arranged side by side, and shall be the same height. Flush mounted cabinets should be 1-1/2 inches apart and coupled by conduit nipple.
5. Gutter sizes in panel boxes, on all sides, shall be in accordance with the NEC. Cabinets containing through feeders shall have the gutter space increased by the amount required for auxiliary gutters in the NEC.

B. Trims:

1. Fabricate trim of sheet steel consisting of frame with door attached by concealed hinges. Provide flush or surface trim as shown on the drawings.
2. Flush trims shall overlap the box by at least 3/4-inch all around.
3. Surface trim shall have the same width and height as the box.
4. Secure trims to boxes by indicating trim clamps.
5. Provide a welded angle on rear of trim to support and align trim to cabinet.
6. Provide separate trims for each section of multiple section panelboards. Trims and doors of sections shall be of the same height.

C. Doors:

1. Provide doors with flush type latch and common-keyed Owner standard lock. Doors over 48 inches in height shall have a vault handle and a three point catch, arranged to fasten door at top, bottom and center.
2. In making switching devices accessible, doors shall not uncover any live parts.
3. Provide concealed, butt hinges welded to the doors and trims.
4. Furnish panelboards with door-in-door trims.

D. Painting: Thoroughly clean and paint trim and doors at the factory with primer and manufacturer's standard finish.

2.3 MOLDED CASE CIRCUIT BREAKERS FOR PANELBOARDS AND LIGHTING CONTROL PANELBOARDS:

A. In accordance with Section 262800, OVERCURRENT PROTECTIVE DEVICES.

2.4 LIGHTING CONTROL PANELBOARDS:

A. Shall comply with requirements for panelboards.

B. Shall have the following additional features:

1. Contain a standalone system controller integral to the lighting control panelboard, which provides scheduling for each solenoid-operated circuit breaker of up to 12 ON and OFF times per day on a weekly schedule. Control will also include astronomical clock, manual bypass ON and OFF for each solenoid-operated circuit breaker, holiday scheduling, integral battery-backed memory protection, diagnostics, and clock.
2. System controller, integrally or by an additional unit integral to the lighting control panelboard, shall allow for connection and monitoring of up to 48 maintained or momentary contact closures from wall switches, occupancy sensors, photocells, building EMCS systems, or dry contacts. Inputs shall be self-powered and able to be individually programmed or time-scheduled to control individual solenoid-operated circuit breakers or groups of such breakers.

C. Internal power supply, self-powered from the lighting control panelboard.

D. Barriers between line and low voltage components.

E. Operable between –5 degrees C and +40 degrees C.

PART 3 EXECUTION

3.1 INSTALLATION:

A. Installation shall be in accordance with NEC, as shown on the drawings, and as herein specified.

B. Identification:

1. Panelboard: Provide panelboard designation, system voltage, and system phases (i.e., "PANEL A 120/208V 3Ø, 4W") on the front door of each panelboard on laminated black (red for emergency power) phenolic nameplate with a white core with ½" engraved lettering. Nameplate shall be secured with #6 self-tapping screws.
2. Provide typed or printed directory card(s), indicating actual room numbers and any other pertinent information for the circuit served. Mount card in metal holder with transparent cover. Minimum card size shall be 5" x 8" for panels with 20 circuits; two for panels with more than 20 circuits; or 6" x 11". Permanently mount holders on inside of doors. [{University of Arizona} Verify actual room numbers with the Construction Project Manager].

C. Balance with loads on all phases and rearrange branch circuiting, if required, for balancing.

D. Locate panelboards so that the present and future conduits can be conveniently connected. Coordinate the sizes of cabinets with designated closet space.

E. Mount the panelboard so that maximum height of circuit breakers above finished floor shall not exceed 78 inches. For panelboards that are too high, mount panelboard so that the bottom of the cabinets will not be less than six inches above the finished floor.

[F. For panelboards located in areas accessible to the public, paint the exposed surfaces of the trims, doors, and boxes with finishes to match surrounding surfaces after the panelboards have been installed. Panelboards located in electric closets shall have manufacturers standard finish.]

G. In wet or damp locations, install panelboards on steel channel supports secured to wall.

H. Torque all lugs as per manufacturer's specifications.

I. Clean filings, dust, and debris from panelboard interiors.

J. Provide and install spare conduits in accordance with section 260533.

K. Provide programming, testing, and startup for lighting control panelboards. Include as-left schedule information in the operation and maintenance manual.

END OF SECTION 262416

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 262726 - WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Receptacles, receptacles with integral GFCI, and associated device plates.
2. Twist-locking receptacles.
3. Weather-resistant receptacles.
4. Solid-state fan speed controls.
5. Cord and plug sets.

1.3 DEFINITIONS

A. EMI: Electromagnetic interference.

B. GFCI: Ground-fault circuit interrupter.

C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

D. RFI: Radio-frequency interference.

E. TVSS: Transient voltage surge suppressor.

F. UTP: Unshielded twisted pair.

1.4 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Receptacles for Owner-Furnished Equipment: Match plug configurations.
2. Cord and Plug Sets: Match equipment requirements.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

C. Samples: One for each type of device and wall plate specified, in each color specified.

1.6 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 GENERAL WIRING-DEVICE REQUIREMENTS

A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70.

C. Devices that are manufactured for use with modular plug-in connectors may be substituted under the following conditions:

1. Connectors shall comply with UL 2459 and shall be made with stranding building wire.
2. Devices shall comply with the requirements in this Section.

2.3 STRAIGHT-BLADE RECEPTACLES

A. Convenience and GFCI non-feed-through Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596. Heavy duty specification grade, brass strap, ivory color, with integral connector and pre-stripped leads.

1. Basis of Design product is Pass and Seymour Plug Tail. Equivalent products may be used as manufactured by:

a. Legrand
b. Hubbell.
c. Leviton.

2.4 CONTROLLED STRAIGHT-BLADE RECEPTACLES

A. Convenience and GFCI non-feed-through Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596. Heavy duty specification grade, brass strap, ivory color, with integral connector and pre-stripped leads.

B. Controlled receptacles shall be with "Controlled Receptacle Marking Symbol" and the word "CONTROLLED" per 2017 NEC Article 406.3(E),

1. Basis of Design product is Pass and Seymour Plug Tail. Equivalent products may be used as manufactured by:

a. Legrand
b. Hubbell.
c. Leviton.

2.5 GFCI RECEPTACLES

A. General Description: Per above. In addition:

1. Straight blade, feed-through type.
2. Comply with NEMA WD 1, NEMA WD 6, UL 498, UL 943 Class A, and FS W-C-596.
3. Include indicator light that shows when the GFCI has malfunctioned and no longer provides proper GFCI protection.

B. Duplex GFCI Convenience Receptacles, 125 V, 20 A:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Legrand
b. Hubbell.
c. Leviton.

2.6 TWIST-LOCKING RECEPTACLES

A. Single Convenience Receptacles, 125 V and 250V, 20 A and 30A: Comply with NEMA WD 1, NEMA WD 6 Configurations as shown on drawings, and UL 498. Refer to general requirements above.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Legrand
b. Hubbell.
c. Leviton.

2.7 CORD AND PLUG SETS

A. Description:

1. Match voltage and current ratings and number of conductors to requirements of equipment being connected.
2. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and ampacity of at least 130 percent of the equipment rating.
3. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.8 TOGGLE SWITCHES

A. Comply with NEMA WD 1, UL 20, and FS W-S-896.

B. Switches, 120/277 V, 20 A:

1. Basis of Design is Pass and Seymour Plug Tail. Equivalent products include manufacturers:

1) Legrand
2) Hubbell.
3) Leviton.

2.9 WALL PLATES

A. Stainless steel, satin finish, 0.035 inches thick.

1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces: Smooth, high-impact thermoplastic.
3. Material for Damp Locations: Thermoplastic with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.

B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, die-cast aluminum with lockable cover.

2.10 FINISHES

A. Device Color:

1. Wiring Devices Connected to Normal Power System: Ivory unless otherwise indicated or required by NFPA 70 or device listing.
2. Wiring Devices Connected to Emergency Power System: Red.

B. Wall Plates: Stainless steel, satin finish, minimum 0.035" thick.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.

B. Coordination with Other Trades:

1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.

D. Device Installation:

1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits. Devices shall not be used as a terminal strip for downstream devices.
5. Use a torque screwdriver when a torque is recommended or required by manufacturer.
6. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the right.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

3.2 GFCI RECEPTACLES

A. Install non-feed-through-type GFCI receptacles where protection of downstream receptacles is not required.

3.3 IDENTIFICATION

A. Comply with Section 260553 "Identification for Electrical Systems."

B. Identify each wiring device with panelboard identification and circuit number. Use hot, stamped, or engraved machine printing with black-filled 1/2" lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Test Instruments: Use instruments that comply with UL 1436.

2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

B. Tests for Convenience Receptacles:

1. Line Voltage: Acceptable range is 105 to 132 V.
2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mounted.
6. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

C. Test straight-blade for the retention force of the grounding blade according to NFPA 99. Retention force shall be not less than 4 oz.

D. Wiring device will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

END OF SECTION 26-27-26

SECTION 262800 - OVERCURRENT PROTECTIVE DEVICES

PART 1 GENERAL

1.1 DESCRIPTION:

A. Overcurrent protective devices for panelboards.

1.2 WORK INCLUDED:

A. Circuit breakers.

1.3 RELATED WORK:

A. Section 260050: Basic ELECTRICAL Methods and Requirements

1.4 SUBMITTALS:

A. Shop Drawings:

1. Include device type, frame and trip ratings, voltage and AIC ratings, mounting, and accessories.

1.5 APPLICABLE PUBLICATIONS: Publications listed below (including amendments, addenda, revisions, supplements and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by basic designation only.

A. Institute of Engineering and Electronic Engineers (IEEE):

C37.13-90 ..... Low Voltage AC Power Circuit Breakers Used in Enclosures

C37.51-89 ..... Test Procedures for Low-voltage AC Power Circuit Breakers Used in Enclosures.

C57.13-93 ..... Instrument Transformers

C62.41-91 ..... Surge Voltage in Low Volume AC Power Circuits

C62.45-92 ..... Testing for Equipment connected to Low-Voltage AC Power Circuits

B. National Electrical Manufacturer's Association (NEMA):

PB-2-95 ..... Dead-Front Distribution Switchboards.

PB-2.1-96 ..... Instructions for Safe Handling, Installation, Operation, and Maintenance of Switchboards

AB-1-93 ..... Molded Case Circuit Breakers

C. National Fire Protection Association (NFPA):

70-99 ..... National Electrical Code (NEC)

D. Underwriters Laboratories, Inc. (UL):

67-93 ..... Panelboards

489-96 ..... Molded Case Circuit Breakers and Circuit Breakers Enclosures

891-98 ..... Dead-Front Switchboards

1283-98 ..... Electromagnetic Interference Filters

PART 2 PRODUCTS

2.1 MOLDED CASE CIRCUIT BREAKERS FOR BRANCH CIRCUIT PANELBOARDS:

A. Breakers shall be UL listed and labeled, in accordance with the NEC, as shown on the drawings, and as herein specified. Breakers shall be products of the panelboard manufacturer, listed for use in the equipment in which installed.

B. Breakers shall be standard-rated unless otherwise noted.

C. Circuit breakers shall be bolt-on type for 277/480V panelboards and plug-on type for 120/208V panelboards, unless otherwise indicated.

D. Construction:

1. Each breaker shall consist of molded case frame, operating mechanism, arc extinguishers, contacts, trip elements, and terminal connectors.
2. The operating mechanism shall be toggle type, quick-make, quick-break, trip free. The handle shall be clearly marked with the rating, and shall indicate the position (ON, OFF or TRIPPED). Multi-pole breakers shall have common trips. The contacts shall be silver alloy. The breaker shall have an arc quenchers and phase barriers for each pole. An overload on one pole of a multi-pole breaker shall automatically cause all the poles of the breaker to open.

    a. The following materials shall not be acceptable: tie handles on circuit breakers; tandem, duplex, wafer breakers, etc.

3. Breakers shall have noninterchangeable trips except where permitted otherwise in the plans.
4. Two visible forms of Tripped indication, by breaker handle residing between the On and Off positions and by trip indicator appearing in the window of the circuit breaker housing.

E. Rating: New molded case circuit breakers in existing panelboard shall have minimum interrupting to match existing breaker's AIC rating.

2.2 SWITCHBOARD MOLDED CASE CIRCUIT BREAKERS:

A. Switchboard circuit breakers may be installed in panelboards as main devices. Breakers shall be products of the switchboard manufacturer, listed for use in the equipment in which installed..

B. Construction:

1. Each breaker shall consist of bolt-on molded case frame, operating mechanism, arc extinguishers, contacts, trip elements, and terminal connectors.
2. The operating mechanism shall be quick-make, quick-break, overcenter toggle-type, and the handle mechanism shall be trip free to prevent holding the contacts closed against a short circuit or sustained overload. The handle shall be clearly marked with the rating, and shall indicate the position (ON, OFF or TRIPPED). Multi-pole breakers shall have common trips. An overload on one pole of a multi-pole breaker shall automatically cause all the poles of the breaker to open.

C. Rating:

1. Voltage rating shall not be less than the applicable circuit voltage.
2. The interrupting rating shall be at least equal to the available short circuit current at the line terminals of the circuit breaker and correspond to the UL listed integrated short circuit current rating specified for the panelboards. Available short circuit currents are shown on plans.
3. Breakers shall be standard-rated unless otherwise noted.

D. Solid state trip elements:

1. Solid state electronics shall be self-contained and require no external relaying, power supply, or accessories. Sensing shall measure true RMS current and shall be toroidal construction, epoxy-encased, and integral to the circuit breaker. Circuit breakers shall have tripping functions as shown on the drawings and as described below:

a. Long-time current pickup, adjustable from 50 percent to 100 percent on continuous current rating.
b. Adjustable long-time delay.
c. Short-time current pickup, adjustable from 1.5 to 9 times long-time current rating.
d. Adjustable short-time delay.
e. Instantaneous current pickup, adjustable from 1.5 to 9 times long-time current rating.
f. Ground-fault pickup, adjustable from 20 percent to 60 percent of sensor rating, but not greater than 1200 amperes. Sensing of ground fault current at the main bonding jumper or ground strap is not acceptable. Zone-selective interlocking shall be provided where shown.
g. Adjustable ground-fault delay.
h. Overload and short-time and ground-fault trip indicators shall be provided.

E. Frame size:

1. Where frame size shown is insufficient to land conductors shown on plans, provide manufacturer's accessory lug kits or increase breaker frame size to accommodate conductors shown.

F. Accessories:

1. Circuit breakers shall have accessories or auxiliary functions as shown on plans.

PART 3 EXECUTION

3.1 CIRCUIT BREAKERS:

A. Shall be installed according to NEC, and manufacturer's recommendations.

B. Torque all lugs per manufacturer's specifications.

END OF SECTION 262800

SECTION 262813 - FUSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Cartridge fuses rated 600-V ac and less for use in enclosed switches and enclosed controllers.
2. Plug fuses rated 125-V ac and less for use in plug-fuse-type enclosed switches.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material, dimensions, descriptions of individual components, and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:

1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.

a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.

2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.

3. Current-limitation curves for fuses with current-limiting characteristics.

4. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse

5. Coordination charts and tables and related data.

6. Fuse sizes for elevator feeders and elevator disconnect switches.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Ambient temperature adjustment information.

2. Current-limitation curves for fuses with current-limiting characteristics.
3. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse.
4. Coordination charts and tables and related data.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than 3 of each size and type.

1.6 QUALITY ASSURANCE

A. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NEMA FU 1 for cartridge fuses.

D. Comply with NFPA 70.

E. Comply with UL 248-11 for plug fuses.

1.7 PROJECT CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F or more than 100 deg F, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

1.8 COORDINATION

A. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, the following:

1. Cooper Bussmann, Inc.
2. Littelfuse, Inc.

2.2 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.

B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.

C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FUSE APPLICATIONS

A. Cartridge Fuses:

1. Class RK1, time delay.

3.3 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

3.4 IDENTIFICATION

A. Install labels complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems" and indicating fuse replacement information on inside door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION 262813

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 262816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fusible switches.
2. Nonfusible switches.
3. Shunt trip switches.
4. Molded-case circuit breakers (MCCBs).
5. Molded-case switches.
6. Enclosures.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include nameplate ratings, dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.4 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

1.5 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: One year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single manufacturer.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

D. Comply with NFPA 70.

2.2 FUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.

B. Type HD, Heavy Duty:

1. Single throw.
2. Three pole.
3. 240 and 600 V ac.
4. 1200 A and smaller
5. UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses.
6. Lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
5. Service-Rated Switches: Labeled for use as service equipment.

2.3 NONFUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.

B. Type HD, Heavy Duty, Three Pole, Single Throw, 240 and 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
5. Service-Rated Switches: Labeled for use as service equipment.

2.4 SHUNT TRIP SWITCHES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.
5. Cooper Bussmann, Inc.

B. General Requirements: Comply with ASME A17.1, UL 50, and UL 98, with Class J fuse block and 200-kA interrupting and short-circuit current rating.

C. Type HD, Heavy-Duty, Three Pole, Single-Throw Fusible Switch: 240 and 600-V ac; UL 98 and NEMA KS 1; integral shunt trip mechanism; horsepower rated, with clips or bolt pads to accommodate specified fuses; lockable handle with capability to accept three padlocks; interlocked with cover in closed position.

D. Control Circuit: 120-V ac; obtained from integral control power transformer, with primary and secondary fuses, with a control power transformer of enough capacity to operate shunt trip, pilot, indicating and control devices.

E. Accessories:

1. Oiltight key switch for key-to-test function.
2. Oiltight red ON pilot light.
3. Isolated neutral lug; 100 percent rating.
4. Mechanically interlocked auxiliary contacts that change state when switch is opened and closed.
5. Three-pole, double-throw, fire-safety and alarm relay; 24-V dc coil voltage.
6. Three-pole, double-throw, fire-alarm voltage monitoring relay complying with NFPA 72.
7. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
8. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
9. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
10. Service-Rated Switches: Labeled for use as service equipment.

2.5 MOLDED-CASE CIRCUIT BREAKERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.

B. Circuit breakers shall be constructed using glass-reinforced insulating material. Current carrying components shall be completely isolated from the handle and the accessory mounting area.

C. Circuit breakers shall have a toggle operating mechanism with common tripping of all poles, which provides quick-make, quick-break contact action. The circuit-breaker handle shall be over center, be trip free, and reside in a tripped position between on and off to provide local trip indication. Circuit-breaker escutcheon shall be clearly marked on and off in addition to providing international I/O markings. Equip circuit breaker with a push-to-trip button, located on the face of the circuit breaker to mechanically operate the circuit-breaker tripping mechanism for maintenance and testing purposes.

D. The maximum ampere rating and UL, IEC, or other certification standards with applicable voltage systems and corresponding interrupting ratings shall be clearly marked on face of circuit breaker. Circuit breakers shall be 100 percent rated for connected interrupting ratings. Any series rated combination used shall be marked on the end-use equipment along with the statement "Caution - Series Rated System. _____ Amps Available. Identical Replacement Component Required."

E. MCCBs shall be equipped with a device for locking in the isolated position.

F. Lugs shall be suitable for 167 deg F rated wire.

G. Standards: Comply with UL 489 with interrupting capacity to comply with available fault currents.

H. Thermal-Magnetic Circuit Breakers: Inverse time-current thermal element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger unless otherwise indicated on drawings.

I. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

J. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:

1. Long- and short-time pickup levels.
2. Long- and short-time time adjustments.
3. Ground-fault pickup level, time delay, and I-squared t response.

K. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.

L. Features and Accessories:

1. Standard frame sizes, trip ratings, and number of poles.
2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.

2.6 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: UL 489, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

B. Enclosure Finish: The enclosure shall be finished with gray baked enamel paint, electrodeposited on cleaned, phosphatized steel (NEMA 250 Type 1)

C. Conduit Entry: NEMA 250 Types 4, 4X, and 12 enclosures shall contain no knockouts. NEMA 250 Types 7 and 9 enclosures shall be provided with threaded conduit openings in both endwalls.

D. Operating Mechanism: The circuit-breaker operating handle shall be externally operable with the operating mechanism being an integral part of the box, not the cover. The cover interlock mechanism shall have an externally operated override. The override shall not permanently disable the interlock mechanism, which shall return to the locked position once the override is released. The tool used to override the cover interlock mechanism shall not be required to enter the enclosure in order to override the interlock.

E. Enclosures designated as NEMA 250 Type 4, 4X stainless steel, 12, or 12K shall have a dual cover interlock mechanism to prevent unintentional opening of the enclosure cover when the circuit breaker is ON and to prevent turning the circuit breaker ON when the enclosure cover is open.

F. NEMA 250 Type 7/9 enclosures shall be furnished with a breather and drain kit to allow their use in outdoor and wet location applications.

PART 3 - EXECUTION

3.1 ENCLOSURE ENVIRONMENTAL RATING APPLICATIONS

A. Enclosed Switches and Circuit Breakers: Provide enclosures at installed locations with the following environmental ratings.

1. Indoor, Dry and Clean Locations: NEMA 250, Type 1
2. Outdoor Locations: NEMA 250, Type 3R
3. Wash-Down Areas: NEMA 250, Type 4XNon-metallic
4. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4
5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.

3.2 INSTALLATION

A. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Construction Manager no fewer than 14 days in advance of proposed interruption of electric service.
2. Indicate method of providing temporary electric service.
3. Do not proceed with interruption of electric service without Construction Manager's written permission.
4. Comply with NFPA 70E.

B. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

C. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

D. Temporary Lifting Provisions: Remove temporary lifting of eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

E. Install fuses in fusible devices.

F. Comply with NFPA 70 and NECA 1.

G. Set field-adjustable circuit-breaker trip ranges as specified in "Coordination Studies."

3.3 IDENTIFICATION

A. Comply with requirements in Section 260553 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.4 FIELD QUALITY CONTROL

A. Tests and Inspections for Switches:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect anchorage, alignment, grounding, and clearances.
c. Verify that the unit is clean.
d. Verify blade alignment, blade penetration, travel stops, and mechanical operation.
e. Verify that fuse sizes and types match the Specifications and Drawings.
f. Verify that each fuse has adequate mechanical support and contact integrity.
g. Inspect bolted electrical connections for high resistance using one of the two following methods:

1) Use a low-resistance ohmmeter.

a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.

a) Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.

h. Verify that operation and sequencing of interlocking systems is as described in the Specifications and shown on the Drawings.
i. Verify correct phase barrier installation.
j. Verify lubrication of moving current-carrying parts and moving and sliding surfaces.

2. Electrical Tests:

a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
b. Measure contact resistance across each switchblade fuseholder. Drop values shall not exceed the high level of the manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
c. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1 from the NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.
d. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.
e. Perform ground fault test according to NETA ATS 7.14 "Ground Fault Protection Systems, Low-Voltage."

B. Tests and Inspections for Molded Case Circuit Breakers:

1. Visual and Mechanical Inspection:

a. Verify that equipment nameplate data are as described in the Specifications and shown on the Drawings.
b. Inspect physical and mechanical condition.
c. Inspect anchorage, alignment, grounding, and clearances.
d. Verify that the unit is clean.
e. Operate the circuit breaker to ensure smooth operation.
f. Inspect bolted electrical connections for high resistance using one of the two following methods:

1) Use a low-resistance ohmmeter.

a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.

a) Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.

g. Inspect operating mechanism, contacts, and chutes in unsealed units.
h. Perform adjustments for final protective device settings in accordance with the coordination study.

2. Electrical Tests:

a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
b. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with circuit breaker closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1 from the NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.
c. Perform a contact/pole resistance test. Drop values shall not exceed the high level of the manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
d. Perform insulation resistance tests on all control wiring with respect to ground. Applied potential shall be 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable. Test duration shall be one minute. For units with solid state components, follow manufacturer's recommendation. Insulation resistance values shall be no less than two megohms.
e. Determine the following by primary current injection:

1) Long-time pickup and delay. Pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
2) Short-time pickup and delay. Short-time pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
3) Ground-fault pickup and time delay. Ground-fault pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
4) Instantaneous pickup. Instantaneous pickup values shall be as specified and within manufacturer's published tolerances.

f. Test functionality of the trip unit by means of primary current injection. Pickup values and trip characteristics shall be as specified and within manufacturer's published tolerances.
g. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data. Minimum pickup voltage of the shunt trip and close coils shall be as indicated by manufacturer.
h. Verify correct operation of auxiliary features such as trip and pickup indicators; zone interlocking; electrical close and trip operation; trip-free, anti-pump function; and trip unit battery condition. Reset all trip logs and indicators. Investigate units that do not function as designed.
i. Verify operation of charging mechanism. Investigate units that do not function as designed.

3. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

C. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

1. Test procedures used.
2. Include identification of each enclosed switch and circuit breaker tested and describe test results.
3. List deficiencies detected, remedial action taken, and observations after remedial action.

END OF SECTION 262816

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 262913.03 - MANUAL AND MAGNETIC MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Manual motor controllers.
2. Enclosed full-voltage magnetic motor controllers.
3. Enclosures.
4. Accessories.
5. Identification.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For each type of magnetic controller.

1. Include plans, elevations, sections, and mounting details.
2. Indicate dimensions, weights, required clearances, and location and size of each field connection.
3. Wire Termination Diagrams and Schedules: Include diagrams for signal, and control wiring. Identify terminals and wiring designations and color-codes to facilitate installation, operation, and maintenance. Indicate recommended types, wire sizes, and circuiting arrangements for field-installed wiring, and show circuit protection features. Differentiate between manufacturer-installed and field-installed wiring.
4. Include features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for magnetic controllers, from manufacturer.

B. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

B. UL Compliance: Fabricate and label magnetic motor controllers to comply with UL 508 and UL 60947-4-1.

C. NEMA Compliance: Fabricate motor controllers to comply with ICS 2.

2.2 MANUAL MOTOR CONTROLLERS

A. Motor-Starting Switches (MSS): "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off or on.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Legrand
b. Hubbell.
c. Leviton.

2. Standard: Comply with NEMA ICS 2, general purpose, Class A.
3. Configuration: Nonreversing
4. Surface mounting.

B. Fractional Horsepower Manual Controllers (FHPMC): "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Legrand
b. Hubbell.
c. Leviton.

2. Configuration: Nonreversing
3. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 10 tripping characteristics; heaters matched to nameplate full-load current of actual protected motor; external reset push button; bimetallic type

2.3 ENCLOSED FULL-VOLTAGE MAGNETIC MOTOR CONTROLLERS

A. Description: Across-the-line start, electrically held, for nominal system voltage of 600-V ac and less.

B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.

2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.

C. Standard: Comply with NEMA ICS 2, general purpose, Class A.

D. Configuration: Nonreversing

E. Contactor Coils: Pressure-encapsulated type

1. Operating Voltage: Manufacturer's standard, unless indicated.

F. Control Power:

1. For on-board control power, obtain from line circuit or from integral CPT. The CPT shall have capacity to operate integral devices and remotely located pilot, indicating, and control devices.

a. Spare CPT Capacity as Indicated on Drawings: 50VA.

G. Overload Relays:

1. Thermal Overload Relays:

a. Inverse-time-current characteristic.
b. Class 10tripping characteristic.
c. Heaters in each phase shall be matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
d. Ambient compensated.
e. Automatic resetting.

2.4 ENCLOSURES

A. Comply with NEMA 250, type designations as indicated on Drawings, complying with environmental conditions at installed location.

B. The construction of the enclosures shall comply with NEMA ICS 6.

2.5 ACCESSORIES

A. General Requirements for Control Circuit and Pilot Devices: NEMA ICS 5; factory installed in controller enclosure cover unless otherwise indicated.

1. Push Buttons, Pilot Lights, and Selector Switches: Standard-duty, except as needed to match enclosure type. Heavy-duty or oil-tight where indicated in the controller schedule.

a. Push Buttons: As indicated in the controller schedule.
b. Pilot Lights: As indicated in the controller schedule.

2.6 IDENTIFICATION

A. Controller Nameplates: as described in Section 260553 "Identification for Electrical Systems," for each compartment, mounted with corrosion-resistant screws.

B. Arc-Flash Warning Labels:

1. Comply with requirements in Section 260553 "Identification for Electrical Systems." Produce a 3.5-by-5-inch self-adhesive equipment label for each work location included in the analysis. Labels shall be machine printed, with no field-applied markings.

a. The label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:

1) Location designation.
2) Nominal voltage.
3) Flash protection boundary.
4) Hazard risk category.
5) Incident energy.
6) Working distance.
7) Engineering report number, revision number, and issue date.

b. Labels shall be machine printed, with no field-applied markings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Wall-Mounted Controllers: Install magnetic controllers on walls with tops at uniform height indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems" unless otherwise indicated.

C. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

D. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

E. Setting of Overload Relays: Select and set overloads on the basis of full-load current rating as shown on motor nameplate. Adjust setting value for special motors as required by NFPA 70 for motors that are high-torque, high-efficiency, and so on.

3.2 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.3 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Comply with the provisions of NFPA 70B, "Testing and Test Methods" Chapter.
2. Visual and Mechanical Inspection

a. Compare equipment nameplate data with drawings and specifications.
b. Inspect physical and mechanical condition.
c. Inspect anchorage, alignment, and grounding.
d. Verify the unit is clean.
e. Inspect contactors:

1) Verify mechanical operation.
2) Verify contact gap, wipe, alignment, and pressure are according to manufacturer's published data.

f. Motor-Running Protection:

1) Verify overload element rating is correct for its application.
2) If motor-running protection is provided by fuses, verify correct fuse rating.

g. Inspect bolted electrical connections for high resistance using one of the two following methods:

1) Use a low-resistance ohmmeter. Compare bolted connection resistance values with values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data or NETA ATS Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.

h. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

3. Electrical Tests

a. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Insulation-resistance values shall be according to manufacturer's published data or NETA ATS Table 100.1. In the absence of manufacturer's published data, use Table 100.5. Values of insulation resistance less than those of this table or manufacturer's recommendations shall be investigated and corrected.

b. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.
c. Test motor protection devices according to manufacturer's published data.
d. Test circuit breakers as follows:

1) Operate the circuit breaker to ensure smooth operation.
2) For adjustable circuit breakers, adjust protective device settings according to the coordination study. Comply with coordination study recommendations.

e. Perform operational tests by initiating control devices.

B. Motor controller will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.4 SYSTEM FUNCTION TESTS

A. System function tests shall prove the correct interaction of sensing, processing, and action devices. Perform system function tests after field quality control tests have been completed and all components have passed specified tests.

1. Develop test parameters and perform tests for the purpose of evaluating performance of integral components and their functioning as a complete unit within design requirements and manufacturer's published data.
2. Verify the correct operation of interlock safety devices for fail-safe functions in addition to design function.
3. Verify the correct operation of sensing devices, alarms, and indicating devices.

B. Motor controller will be considered defective if it does not pass the system function tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 262913.03

SECTION 262923 - VARIABLE-FREQUENCY MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes separately enclosed, preassembled, combination VFCs, rated 600V and less, for speed control of three-phase, squirrel-cage induction motors.

1.2 DEFINITIONS

A. CE: Conformite Europeene (European Compliance).

B. CPT: Control power transformer.

C. DDC: Direct digital control.

D. EMI: Electromagnetic interference.

E. OCPD: Overcurrent protective device.

F. PID: Control action, proportional plus integral plus derivative.

G. RFI: Radio-frequency interference.

H. VFC: Variable-frequency motor controller.

1.3 ACTION SUBMITTALS

A. Product Data: For each type and rating of VFC indicated.

B. Shop Drawings: For each VFC indicated.

1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Product certificates.

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1.7 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace VFCs that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. ABB ACH series, 550.

2.2 SYSTEM DESCRIPTION

A. General Requirements for VFCs:

1. VFCs and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508A.

B. VFC Description: Variable-frequency motor controller, consisting of power converter that employs pulse-width-modulated inverter, factory built and tested in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.

1. Units suitable for operation of NEMA MG 1 motors.
2. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.

C. Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

D. Output Rating: Three phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range; maximum voltage equals input voltage.

E. Unit Operating Requirements:

1. Input AC Voltage Tolerance: Plus 10 and minus 10 percent of VFC input voltage rating.
2. Input AC Voltage Unbalance: Not exceeding 3 percent.
3. Input Frequency Tolerance: Plus or minus 3 percent of VFC frequency rating.
4. Minimum Efficiency: 97 percent at 60 Hz, full load.
5. Minimum Displacement Primary-Side Power Factor: 98 percent under any load or speed condition.
6. Minimum Short-Circuit Current (Withstand) Rating: 100 kAIC without need for fuses.
7. Ambient Temperature Rating: Not less than 32 deg F and not exceeding 104 deg F.
8. Humidity Rating: Less than 95 percent (noncondensing).
9. Altitude Rating: Not exceeding 3300 feet.
10. Vibration Withstand: Comply with NEMA ICS 61800-2.
11. Overload Capability: 110% of normal duty rating for 60 seconds every 10 minutes and 130% overload for two seconds.
12. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.
13. Speed Regulation: Plus or minus 5 percent.
14. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.

F. Isolated Control Interface: Allows VFCs to follow remote-control signal over a minimum 40:1 speed range.

1. Signal: Electrical.

G. Self-Protection and Reliability Features:

1. Surge Suppression: Factory installed as an integral part of the VFC, complying with UL 1449 SPD, Type 1 or Type 2.
2. Surge Suppression: Field-mounted surge suppressors complying with Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits," UL 1449 SPD, Type 2.
3. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
4. Under- and overvoltage trips.
5. Inverter overcurrent trips.
6. VFC and Motor-Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFCs and motor thermal characteristics, and for providing VFC overtemperature and motor-overload alarm and trip; settings selectable via the keypad.
7. Critical frequency rejection, with three selectable, adjustable deadbands.
8. Instantaneous line-to-line and line-to-ground overcurrent trips.
9. Loss-of-phase protection.
10. Reverse-phase protection.
11. Short-circuit protection.
12. Motor-overtemperature fault.

H. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.

I. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped, unless "Bidirectional Autospeed Search" feature is available and engaged.

J. Bidirectional Autospeed Search: Capable of starting VFC into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.

K. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

L. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

2.3 CONTROLS AND INDICATION

A. Status Lights: Door-mounted LED indicators displaying the following conditions:

1. Power on.
2. Run.
3. Overvoltage.
4. Line fault.
5. Overcurrent.
6. External fault.

B. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English-language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.

1. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.
2. Security Access: Provide electronic security access to controls through identification and password with at least one level of access: View only; view and operate; and view, operate, and service.

a. Control Authority: Supports at least four conditions: Off, local manual control at VFC, local automatic control at VFC, and automatic control through a remote source.

C. Historical Logging Information and Displays:

1. Real-time clock with current time and date.
2. Running log of total power versus time.
3. Total run time.
4. Fault log, maintaining last four faults with time and date stamp for each.

D. Indicating Devices: Digital display and additional readout devices as required, mounted flush in VFC door and connected to display VFC parameters including, but not limited to:

1. Output frequency (Hz).
2. Motor speed (rpm).
3. Motor status (running, stop, fault).
4. Motor current (amperes).
5. Motor torque (percent).
6. Fault or alarming status (code).
7. PID feedback signal (percent).

8. DC-link voltage (V dc).
9. Set point frequency (Hz).
10. Motor output voltage (V ac).

2.4 BYPASS SYSTEMS

A. Bypass Operation: Manually transfers motor between power converter output and bypass circuit. Unit is capable of stable operation (starting, stopping, and running) with motor completely disconnected from power converter.

B. Bypass Mode: Manual operation only; requires local operator selection at VFC. Transfer between power converter and bypass contactor, and retransfer shall only be allowed with the motor at zero speed.

C. Bypass Controller: Two-contactor-style bypass allows motor operation via the power converter or the bypass controller.

1. Bypass Contactor: Load-break, IEC-rated contactor.
2. Output Isolating Contactor: Non-load-break, IEC-rated contactor.
3. Isolating Switch: Non-load-break switch arranged to isolate power converter and permit safe troubleshooting and testing of the power converter, both energized and de-energized, while motor is operating in bypass mode; pad-lockable, door-mounted handle mechanism.

D. Bypass Contactor Configuration: Full-voltage (across-the-line) type.

1. NORMAL/BYPASS selector switch.
2. HAND/OFF/AUTO selector switch.
3. NORMAL/TEST Selector Switch: Allows testing and adjusting of VFC while the motor is running in the bypass mode.
4. Control Circuits: 120-V ac; obtained from of sufficient capacity to operate all integral devices and remotely located pilot, indicating, and control devices.

    a. CPT Spare Capacity: 100 VA.

5. Overload Relays: NEMA ICS 2.

2.5 ENCLOSURES

A. VFC Enclosures: NEMA 250, to comply with environmental conditions at installed location.

1. Dry and Clean Indoor Locations: Type 1.
2. Outdoor Locations: Type 3R.
3. Other Wet or Damp Indoor Locations: Type 3R.

B. Plenum Rating: UL 1995; NRTL certification label on enclosure, clearly identifying VFC as "Plenum Rated."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Wall-Mounting Controllers: Install with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished floor, unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems."

B. Seismic Bracing: Comply with requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Install fuses in each fusible-switch VFC.

E. Install fuses in control circuits if not factory installed. Comply with requirements in Section 262813 "Fuses."

F. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors are installed.

G. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.

H. Comply with NECA 1.

3.2 CONTROL WIRING INSTALLATION

A. Install wiring between VFCs and remote devices and facility's central-control system.

B. Bundle, train, and support wiring in enclosures.

3.3 IDENTIFICATION

A. Identify VFCs, components, and control wiring. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each VFC with engraved nameplate.
3. Label each enclosure-mounted control and pilot device.

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each VFC element, bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:

1. Inspect VFC, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
2. Test insulation resistance for each VFC element, component, connecting motor supply, feeder, and control circuits.
3. Test continuity of each circuit.
4. Verify that voltages at VFC locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Owner before starting the motor(s).
5. Test each motor for proper phase rotation.
6. Perform tests according to the Inspection and Test Procedures for Adjustable Speed Drives stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
8. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

D. VFCs will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies the VFC and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.5 ADJUSTING

A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

B. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

C. Adjust the trip settings of instantaneous-only circuit breakers and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to 6 times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed 8 times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Owner before increasing settings.

D. Set the taps on reduced-voltage autotransformer controllers.

E. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573 "Overcurrent Protective Device Coordination Study."

F. Set field-adjustable pressure switches.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, reprogram, and maintain VFCs.

END OF SECTION 262923

SECTION 265119 - LED INTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the following:

1. Interior lighting fixtures, lamps, LED modules, and LED drivers.
2. Emergency lighting units.
3. Exit signs.
4. Lighting fixture supports.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
2. Testing Agency Certified Data: For indicated luminaires, photometric data certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.

B. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale and coordinated with each other, using input from installers of the items involved.

B. Seismic Qualification Data: For luminaires, accessories, and components, from manufacturer.

C. Product Certificates: For each type of luminaire.

D. Product test reports.

E. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, accredited under the NVLAP for Energy Efficient Lighting Products, and complying with the applicable IES testing standards.

B. Provide luminaires from a single manufacturer for each luminaire type.

C. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

1.6 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

B. Warranty Period: Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Ambient Temperature: 5 to 104 deg F.

1. Relative Humidity: Zero to 95 percent.

2.2 LUMINAIRE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Locate labels where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following lamp characteristics:

a. "USE ONLY" and include specific lamp type.
b. Lamp diameter, shape, size, wattage, and coating.
c. CCT and CRI.

C. Recessed luminaires shall comply with NEMA LE 4.

D. NRTL Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by an NRTL.

E. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

F. Light fixtures, ballasts, and/or drivers shall be fully compatible with lighting control devices. The contractor is responsible for coordinating and verifying the compatibility and interoperability of all lighting and lighting control equipment, whether basis of design of substitutions.

G. Nominal Operating Voltage: As listing in Light Fixture Schedule on drawings.

H. LED Modules:

1. Minimum delivered fixture lumen output as listing in Light Fixture Schedule on drawings.
2. Minimum allowable efficacy of 80lm/W.
3. CRI 80 minimum unless otherwise listed in Light Fixture Schedule on drawings.
4. Rated lamp life of 50,000hours to L70.
5. Dimmable from 100 percent to 1 percent of maximum light output.
6. User-Replaceable Lamps:

    a. Bulb shape complying with ANSI C78.79.
    b. Lamp base complying with ANSI C81.61 or IEC 60061-1.

I. Driver for Led Modules

1. Electronic Drivers for Light Emitting Diode Modules: Include the following features unless otherwise indicated:

    a. Comply with UL Listed "Dry" and "Damp" location.
    b. Minimum efficiency of 80 percent.
    c. Minimum Operating Temperature: -20˚ C. (-4˚ F.)
    d. Input Voltage: 120 to 277 (±10 percent) 60 Hz.
    e. Power Supplies: UL Class 2 output.
    f. Integral short circuit, open circuit and overload protection.
    g. Power Factor (PF): ≥ 0.90.
    h. Total Harmonic Distortion (THD): ≤ 20 percent.
    i. Comply with FCC Title 47 CFR Part 18 Non-consumer RFI/EMI Standards.
    j. Drivers shall be reduction of hazardous substances (ROHS)-compliant.
    k. Minimum Rated Life: 50,000 hours (90% survival @Tcase of 70˚ C).
    l. Comply with FCC Title 47 CFR Part 15 Non-Consumer (Class A).
    m. 5 year parts warranty.

2. Electronic LED Drivers for Dimmer-Controlled Lighting Fixtures: Electronic type.

    a. Dimming Range: 100 to 1 percent of rated lamp lumens unless otherwise indicated..
    b. Compatibility: Certified by manufacturer for use with specific dimming control system and LED type indicated.
    c. Control: Coordinate wiring from drivers to control device to ensure that the driver, controller, and connecting wiring are compatible.

J. Housings:

1. Housing material equivalent to specified fixtures as listing in Light Fixture Schedule on drawings with passive cooling heat sink. Active cooling is prohibited.

2. Powder-coat painted finish equivalent to specified fixtures as listing in Light Fixture Schedule on drawings.

K. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

L. Diffusers and Globes:

1. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
2. Glass: Annealed crystal glass unless otherwise indicated.
3. Lens Thickness: At least 0.125-inch minimum unless otherwise indicated.

M. Standards:

1. RoHS compliant.
2. UL Listing: Listed for damp location.

2.3 MATERIALS

A. Metal Parts:

1. Free of burrs and sharp corners and edges.
2. Sheet metal components shall be steel unless otherwise indicated.
3. Form and support to prevent warping and sagging.

B. Steel:

1. ASTM A 36/A 36M for carbon structural steel.
2. ASTM A 568/A 568M for sheet steel.

C. Stainless Steel:

1. 1. Manufacturer's standard grade.
2. 2. Manufacturer's standard type, ASTM A 240/240 M.

D. Galvanized Steel: ASTM A 653/A 653M.

E. Aluminum: ASTM B 209.

2.4 METAL FINISHES

A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

2.5 EMERGENCY LIGHTING UNIT

A. Internal Type: Self-contained, modular, battery-inverter unit, factory mounted within lighting fixture body and compatible with driver. Comply with UL 924.

1. Emergency Connection: Operate LED(s) continuously for 90 minutes at an output of 10watts. Connect unswitched circuit to battery-inverter unit and switched circuit to fixture ballast.
2. Nightlight Connection: Operate one fluorescent lamp continuously.
3. Test Push Button and Indicator Light: Visible and accessible without opening fixture or entering ceiling space.

a. Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
b. Indicator Light: LED indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.

4. Battery: Sealed, maintenance-free, nickel-cadmium type.
5. Charger: Fully automatic, solid-state, constant-current type with sealed power transfer relay.
6. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED

2.6 EXIT SIGNS

A. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.

B. Internally Lighted Signs:

1. Lamps for AC Operation: LEDs, 50,000 hours minimum rated lamp life.
2. Universal top, end and back mounting.
3. UL listed. Damp location listed.
4. Dual-voltage input capability120 or 277 VAC
5. Field-selectable chevrons
6. 5-year limited warranty.

2.7 LUMINAIRE SUPPORT

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.

C. Wires: ASTM A 641/A 641 M, Class 3, soft temper, zinc-coated steel, 12 gage

D. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.

E. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

C. Install lamps in each luminaire.

D. Supports:

1. Sized and rated for luminaire weight.
2. Able to maintain luminaire position after cleaning and relamping.
3. Provide support for luminaire without causing deflection of ceiling or wall.
4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.

E. Comply with requirements in Section 260519 "Cables, Low-Voltage " for wiring connections.

3.2 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
2. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

B. Luminaire will be considered defective if it does not pass operation tests and inspections.

C. Prepare test and inspection reports.

3.4 STARTUP SERVICE

A. Comply with requirements for startup specified in Section 260923 - Lighting Control Devices & 260800 – Electrical Systems Commissioning Requirements.

END OF SECTION 265119

Section 27 05 26

Grounding and Bonding for Communications Systems

PART 1 – GENERAL

1.1 WORK INCLUDED

A. Provide all labor, materials, and equipment for the complete installation of work called for in the Contract Documents.

1.2 SCOPE OF WORK

A. This section includes the minimum requirements for the equipment and cable installations in communications equipment rooms (Telecommunications Closets).

B. Included in this section are the minimum composition requirements and installation methods for the following:

1. Busbars
2. Bonding accessories

1.3 QUALITY ASSURANCE

A. All cable and equipment shall be installed in a neat and workmanlike manner. All methods of construction that are not specifically described or indicated in the contract documents shall be subject to the control and approval of the Owner or Owner Representative. Equipment and materials shall be of the quality and manufacture indicated. The equipment specified is based upon the acceptable manufactures listed. Where “approved equal” is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.

B. Strictly adhere to all Building Industry Consulting Service International (BICSI), Electronic Industries Alliance (EIA) and Telecommunications Industry Association (TIA) recommended installation practices when installing communications/data cabling.

C. Material and work specified herein shall comply with the applicable requirements of:

1. ANSI/TIA/EIA – 568-C.0 *Commercial Building Telecommunications Cabling Standard*.

2. TIA – 569-C *Commercial Building Standard for Telecommunications Pathways and Space.*

3. ANSI/TIA/EIA – 606-B *Administration Standard for the Telecommunications Infrastructure of Commercial Buildings.*

4. ANSI-J-STD – 607-B *Joint Standard for Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications*.

5. NFPA 70 – *National Electric Code. Current Edition*

6. BICSI – *Telecommunications Distribution Methods Manual. Current Edition*

1.4 SUBMITTALS

A. Provide product data for the following:

1. Manufacturers cut sheets, specifications and installation instructions for all products (submit with bid).

PART 2 – PRODUCTS

2.1 WALL-MOUNT BUSBARS

A. Telecommunications Main Grounding Busbar (TMGB)

1. Telecommunications Main Grounding Busbar (TMGB) shall be constructed of .25” (6.4 mm) thick solid copper bar.
2. The busbar shall be 4” (100 mm) high and 20” (510 mm) long and shall have 30 attachment points (two rows of 15 each) for two-hole grounding lugs.
3. The hole pattern for attaching grounding lugs shall meet the requirements of ANSI-J-STD – 607-A and shall accept 27 lugs with 5/8” (15.8 mm) hole centers and 3 lugs with 1” (25.4) mm) hole centers.
4. The busbar shall include wall-mount stand-off brackets, assembly screws and insulators creating a 4” (100 mm) standoff from the wall.
5. The busbar shall be UL Listed as grounding and bonding equipment.
6. Design Make shall be:
   Chatsworth Products, Inc. (CPI),
   Telecommunications Main Grounding Busbar:
   Part Number 40153-020, 20” x 4” (510 mm x 100 mm) Telecommunications Main Grounding Busbar, UL Listed.

B. Telecommunications Main Grounding Busbar (TMGB)

1. Telecommunications Main Grounding Busbar (TMGB) shall be constructed of .25” (6.4 mm) thick solid copper bar.
2. The busbar shall be 4” (100 mm) high and 12” (300 mm) long and shall have 18 attachment points (two rows of 9 each) for two-hole grounding lugs.
3. The hole pattern for attaching grounding lugs shall meet the requirements of ANSI-J-STD – 607-A and shall accept 15 lugs with 5/8” (15. 8 mm) hole centers and 3 lugs with 1” (25.4 mm) hole centers.
4. The busbar shall include wall-mount stand-off brackets, assembly screws and insulators creating a 4” (100 mm) standoff from the wall.
5. The busbar shall be UL Listed as grounding and bonding equipment.
6. Design Make shall be:
   Chatsworth Products, Inc. (CPI),
   Telecommunications Main Grounding Busbar:
   Part Number 40153-012, 12” x 4” (300 mm x 100 mm) Telecommunications Main Grounding Busbar, UL Listed.

C. Telecommunications Grounding Busbar (TGB)

1. Telecommunications Grounding Busbar (TGB) shall be constructed of .25” (6.4 mm) thick solid copper bar.
2. The busbar shall be 2” (50 mm) high and 12” (300 mm) long and shall have 9 attachment points (one row) for two-hole grounding lugs.
3. The hole pattern for attaching grounding lugs shall meet the requirements of ANSI-J-STD – 607-A and shall accept 6 lugs with 5/8” (15.8 mm) hole centers and 3 lugs with 1” (25.4 mm) hole centers.
4. The busbar shall include wall-mount stand-off brackets, assembly screws and insulators creating a 4” (100 mm) standoff from the wall.
5. The busbar shall be UL Listed as grounding and bonding equipment.
6. Design Make shall be:
   Chatsworth Products, Inc. (CPI),
   Telecommunications Grounding Busbar:
   Part Number 13622-012, 12” x 2” (300 mm x 50 mm) Telecommunications Grounding Busbar, UL Listed.

D. Telecommunications Grounding Busbar (TGB)

1. Telecommunications Grounding Busbar (TGB) shall be constructed of .25” (6.4 mm) thick solid copper bar.
2. The busbar shall be 2” (50 mm) high and 10” (250 mm) long and shall have 7 attachment points (one row) for two-hole grounding lugs.
3. The hole pattern for attaching grounding lugs shall meet the requirements of ANSI-J-STD – 607-A and shall accept 4 lugs with 5/8” (15.8 mm) hole centers and 3 lugs with 1” (25.4 mm) hole centers.
4. The busbar shall include wall-mount stand-off brackets, assembly screws and insulators creating a 4” (100 mm) standoff from the wall.
5. The busbar shall be UL Listed as grounding and bonding equipment.
6. Design Make shall be:
   Chatsworth Products, Inc. (CPI),
   Telecommunications Grounding Busbar:
   Part Number 13622-010, 10” x 2” (250 mm x 50 mm) Telecommunications Grounding Busbar, UL Listed.

2.2 RACK-MOUNT BUSBAR

A. Horizontal Rack Busbar

1. Horizontal rack-mount busbar shall be constructed of 3/16” (4.7 mm) thick by 3/4” (19.1 mm) high hard-drawn electrolytic tough pitch 110 alloy copper bar.
2. Bar shall be 19” EIA or 23” rack mounting width (as specified below) for mounting on relay racks or in cabinets.
3. Bar shall have eight 6-32 tapped ground mounting holes on 1” (25.4 mm) intervals and four 0.281” (7.1 mm) holes for the attachment of two-hole grounding lugs.
4. Each bar shall include a copper splice bar of the same material (to transition between adjoining racks) and two each 12-24 x ¾” copper-plated steel screws and flat washers for attachment to the rack or cabinet.

5. Bar shall be UL Listed as grounding and bonding equipment.
6. Design Make shall be:
   Chatsworth Products, Inc. (CPI),
   Horizontal Rack Busbar:
   Part Number 10610-019, Ground Bar for 19” Rack.
   Part Number 10610-023, Ground Bar for 23” Rack.

B. Vertical Rack Busbar

1. Vertical rack-mount busbar shall be constructed of 1/4” (6.4 mm) thick by 5/8” (15.8 mm) high hard-drawn electrolytic tough pitch 110 alloy copper bar.
2. Bar shall be 72” (1830 mm) or 36” (910 mm) high (as specified below) for mounting vertically on relay racks.
3. 72” (1830 mm) high bar shall have 13 threaded 1/4-20 attachment points for two-hole lugs with 5/8” (15.8 mm) hole centers and two pairs of threaded studs (one at top, one at bottom) for two-hole lugs with 1” (25.4 mm) hole centers.
4. 36” (910 mm) high bar shall have 8 threaded 1/4-20 attachment points for two-hole lugs with 5/8” (15.8 mm) hole centers and one pair of threaded studs for a two-hole lug with 1” (2.4 mm) hole centers.
5. Each bar shall include a #2 AWG two-hole compression lug for 1” (25.4 mm) hole centers, insulator blocks and mounting screws.
6. Bar shall be UL Listed as grounding and bonding equipment.
7. Design Make shall be:
   Chatsworth Products, Inc. (CPI),
   Vertical Rack Busbar Kit:
   Part Number 40161-036, Vertical Rack Busbar, 36” (910 mm) H
   Part Number 40161-072, Vertical Rack Busbar, 72” (1830 mm) H

C. Vertical Rack Ground Bar

1. Vertical rack-mount ground bar shall be constructed of .05” (1.3 mm) thick by .68” (17 mm) wide tinned copper strip.
2. Bar shall be 78” (1997 mm) high for mounting vertically on relay racks and shall have holes punched on 5/8”-5/8”-1/2” alternating vertical centers to match the EIA-310-D Universal Hole Pattern for a 45 RMU rack.
3. Each bar shall include three #12-24 zinc-plated thread forming hex washer head installation screws, an abrasive pad and antioxidant joint compound.
4. Bar shall be UL Listed as grounding and bonding equipment.
5. Design Make shall be:
   Chatsworth Products, Inc. (CPI),
   Vertical Rack Ground Bar Kit:
   Part Number 40172-001, Rack Ground Bar Kit, 45 RMU

2.3 BONDING ACCESSORIES

A. Two Mounting Hole Ground Terminal Block

1. Ground terminal block shall be made of electroplated tin aluminum extrusion.
2. Ground terminal block shall accept conductors ranging from #14 AWG through 2/0.
3. The conductors shall be held in place by two stainless steel set screws.

4. Ground terminal block shall have two 1/4” (6.4 mm) holes spaced on 5/8” (15.8 mm) centers to allow secure two-bolt attachment to the rack or cabinet.
5. Ground terminal block shall be UL Listed as a wire connector.
6. Design Make shall be:
   Chatsworth Products, Inc. (CPI),
   Two Mounting Hole Ground Terminal Block:
   Part Number 40167-001, Two Mounting Hole Ground Terminal Block, 1 each

B. Compression Lugs

1. Compression lugs shall be manufactured from electroplated tinned copper.
2. Compression lugs shall have two holes spaced on 5/8” (15.8 mm) or 1” (25.4 mm) centers, as stated below, to allow secure two bolt connections to busbars.
3. Compression lugs shall be sized to fit a specific size conductor, sizes #6 to 4/0, as stated below.
4. Compression lugs shall be UL Listed as wire connectors.
5. Design Make shall be:
   Chatsworth Products, Inc. (CPI),
   Compression Lugs:
   Part Number 40162-901, Compression Lug, #6 Awg, 5/8” (15.8 mm) hole spacing, 1 each.
   Part Number 40162-903, Compression Lug, #6 Awg, 1” (25.4 mm) hole spacing, 1 each.
   Part Number 40162-904, Compression Lug, #2 Awg, 5/8” (15.8 mm) hole spacing, 1 each.
   Part Number 40162-907, Compression Lug, #2 Awg, 1” (25.4 mm) hole spacing, 1 each.
   Part Number 40162-909, Compression Lug, 2/0 Awg, 1” (25. 4 mm) hole spacing, 1 each.
   Part Number 40162-911, Compression Lug, 4/0 Awg, 1” (25.4 mm) hole spacing, 1 each.
   Notes:
   Other sizes are available.

C. Antioxidant Joint Compound

1. Oxide inhibiting joint compound for copper-to-copper, aluminum-to-aluminum or aluminum-to-copper connections.
2. Design Make shall be:
   Chatsworth Products, Inc. (CPI),
   Antioxidant Joint Compound:
   Part Number 40168-101, Antioxidant Joint Compound, Copper-to-Copper Connections, .5 oz, 1 each.
   Part Number 40168-801, Antioxidant Joint Compound, Copper-to-Copper Connections, 8 oz, 1 each.
   Part Number 40166-101, Antioxidant Joint Compound, Aluminum-to-Aluminum or Aluminum-to-Copper Connections, .5 oz, 1 each.
   Part Number 40166-801, Antioxidant Joint Compound, Aluminum-to-Aluminum or Aluminum-to-Copper Connections, 8 oz, 1 each.
   Part Number 40168-150, Antioxidant Joint Compound, Copper-to-Copper Connections, .5 oz, 50 each.

Part Number 40168-812, Antioxidant Joint Compound, Copper-to-Copper Connections, 8 oz, 12 each.
Part Number 40166-150, Antioxidant Joint Compound, Aluminum-to-Aluminum or Aluminum-to-Copper Connections, .5 oz, 50 each.
Part Number 40166-812, Antioxidant Joint Compound, Aluminum-to-Aluminum or Aluminum-to-Copper Connections, 8 oz, 12 each.

D. C-Type, Compression Taps

1. Compression taps shall be manufactured from copper alloy.
2. Compression taps shall be C-shaped connectors that wrap around two conductors forming an irreversible splice around the conductors; installation requires a hydraulic crimping tool
3. Compression taps shall be sized to fit specific size conductors, sizes #2 AWG to 4/0, as stated below.
4. Compression taps shall be UL Listed.
5. Design Make shall be:
   Chatsworth Products, Inc. (CPI),
   Compression Taps:
   Part Number 40163-001, Compression Tap, #6 AWG Solid Run to #6 AWG Solid Tap, 1 each.
   Part Number 40163-007, Compression Tap, 2/0 Stranded Run to 2/0 Stranded Tap, 1 each.
   Notes:
   Other sizes are available.

E. Pedestal Clamp With Grounding Connector

1. Pedestal clamp shall be made from electroplated tinned copper or bronze. Installation hardware will be stainless steel.
2. Pedestal clamps shall be sized to fit a specific size conductor, size #6 and/or 2/0, as stated below.
3. Pedestal clamp installation hardware shall be sized to attach to round and/or square raised access floor pedestals that are 1-1/8” to 1-3/4” in diameter, as stated below.
4. Pedestal clamp shall provide straight (in-line) or cross (intersection) support for up to two conductors.
5. Pedestal clamp shall be UL Listed as grounding and bonding equipment.
6. Design Make shall be:
   Chatsworth Products, Inc. (CPI),
   Pedestal Clamps:
   Part Number 40169-001, Pedestal Clamp, Cross Connector, for 1-1/8” Square Pedestals, with (2) #6 AWG conductors per side, 1 each.
   Part Number 40169-002, Pedestal Clamp, Cross Connector, for 1-1/8” to 1-3/4” Round Pedestals, with (1) #6 AWG and (1) 2/0 conductors per side, 1 each.

F. Pipe Clamp With Grounding Connector

1. Pipe clamp shall be made from electroplated tinned bronze. Installation hardware will be stainless steel.

2. Pipe clamp shall be sized to fit up to two conductors ranging in size from #6 to 250 MCM; conductors must be the same size.
3. Pipe clamp installation hardware shall be sized to attach to pipes, sizes 1" to 6" (.75" to 6.63" in diameter), as stated below.
4. Pipe clamp shall be UL Listed as grounding and bonding equipment.
5. Design Make shall be:
   Chatsworth Products, Inc. (CPI),
   Pipe Clamps:
   Part Number 40170-002, Pipe Clamp, for 1" to 1-1/4" pipe, 1 each.
   Part Number 40170-003, Pipe Clamp, for 1-1/2" to 2" pipe, 1 each.
   Part Number 40170-004, Pipe Clamp, for 2-1/2" to 3" pipe, 1 each.
   Part Number 40170-005, Pipe Clamp, for 3-1/2" to 4" pipe, 1 each.
   Part Number 40170-006, Pipe Clamp, for 5" to 6" pipe, 1 each.

G. Equipment Ground Jumper Kit

1. Kit includes one 24"L insulated ground jumper with a straight two hole compression lug on one end and an L-shaped two hole compression lug on the other end, two plated installation screws, an abrasive pad and a .5 once tube of antioxidant joint compound.
2. Ground conductor is an insulated green/yellow stripe #6 AWG wire
3. Lugs are made from electroplated tinned copper and have two mounting holes spaces .5" to .625" apart that accept 1/4" screws.
4. Jumper will be made with UL Listed components
5. Design Make shall be:
   Chatsworth Products, Inc. (CPI),
   Equipment Ground Jumper Kit:
   Part Number 40159-010, Equipment Ground Jumper Kit, 1 each.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Wall-Mount Busbars
1. Attach busbars to the wall with appropriate hardware according to the manufacturer's installation instructions.
2. Conductor connections to the TMGB or TGB shall be made with two-hole bolt-on compression lugs sized to fit the busbar and the conductors.
3. Each lug shall be attached with stainless steel hardware after preparing the bond according to manufacturer recommendations and treating the bonding surface on the busbar with antioxidant to help prevent corrosion at the bond.
4. The wall-mount busbar shall be bonded to ground as part of the overall Telecommunications Bonding and Grounding System.

B. Rack-Mount Busbars and Ground Bars
1. When a rack or cabinet supports active equipment or any type of shielded cable or cable termination device requiring a ground connection, add a rack-mount horizontal or vertical busbar or ground bar to the rack or cabinet. The rack-mount busbar or ground bar provides multiple bonding points on the rack for rack and rack-mount equipment.

2. Attach rack-mount busbars and ground bars to racks or cabinets according to the manufacturer's installation instructions.
3. Bond the rack-mount busbar or ground bar to the room's TMGB or TGB with appropriately sized hardware and conductor.

C. Ground Terminal Block
1. Every rack and cabinet shall be bonded to the TMGB or TGB.
2. Minimum bonding connection to racks and cabinets shall be made with a rack-mount two-hole ground terminal block sized to fit the conductor and rack and installed according to manufacturer recommendations.
3. Remove paint between rack/cabinet and terminal block, clean surface and use antioxidant between the rack and the terminal block to help prevent corrosion at the bond.

D. Pedestal Clamp
1. At minimum, bond every sixth raised access floor pedestal with a minimum #6 AWG conductor to the TMGB or TGB using a pedestal clamp sized to fit the pedestal and the conductor and installed according to the manufacturer's recommendations.
2. If pedestal clamps are used to construct a signal reference grid, bond the signal reference grid to the TMGB or TGB and bond each rack and/or cabinet to the signal reference grid using a compression tap or similar non-reversible bonding component sized to fit both conductors.
3. Remove paint between the pedestal and pedestal clamp, clean surface and use antioxidant between the pedestal and the clamp to help prevent corrosion at the bond.
4. Remove insulation from conductors where wires attach to the pedestal clamp.

E. Pipe Clamp
1. Bond metal pipes located inside the data center computer room with a minimum #6 AWG conductor to the TMGB or TGB using a pipe clamp sized to fit the pipe and the conductor and installed according to the manufacturer's recommendations.
2. Remove paint between the pipe and pipe clamp, clean surface and use antioxidant between the pipe and the clamp to help prevent corrosion at the bond.
3. Remove insulation from conductors where wires attach to the pipe clamp.

F. Equipment Ground Jumper Kit
1. Bond equipment to a vertical rack-mount busbar or groundbar using ground jumper according to the manufacturer's recommendations.
2. Clean the surface and use antioxidant between the compression lugs on the jumper and the rack-mount busbar or groundbar to help prevent corrosion at the bond.

Section 27 11 00

COMMUNICATIONS EQUIPMENT ROOM FITTINGS

Section 27 11 16

Communications Cabinets, Racks, Frames and Enclosures

PART 1 – GENERAL

1.1 WORK INCLUDED

A. Provide all labor, materials, and equipment for the complete installation of work called for in the Contract Documents.

1.2 SCOPE OF WORK

A. This section includes the minimum requirements for the equipment and cable installations in telecommunications equipment rooms.

B. Included in this section are the minimum composition requirements and installation methods for the following:

Racks.

1.3 QUALITY ASSURANCE

A. All cable and equipment shall be installed in a neat and workmanlike manner. All methods of construction that are not specifically described or indicated in the contract documents shall be subject to the control and approval of the Owner or Owner Representative. Equipment and materials shall be of the quality and manufacture indicated. The equipment specified is based upon the acceptable manufacturers listed. Where “approved equal” is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.

B. Strictly adhere to all Building Industry Consulting Service International (BICSI), Electronic Industries Alliance (EIA) and Telecommunications Industry Association (TIA) recommended installation practices when installing communications/data cabling.

C. Material and work specified herein shall comply with the applicable requirements of:

1. TIA – 569-B Commercial Building Standard for Telecommunications Pathways and Spaces, 2004

2. ANSI/TIA – 568-C Commercial Building Telecommunications Cabling Standard, 2009

3. ANSI/NECA/BICSI 568-2006 – Standard for Installing Commercial Building Telecommunications Cabling

4. TIA – 606-A Administration Standard for Commercial Telecommunications Infrastructure, 2007

5. ANSI-J-STD – 607-A Joint Standard for Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications, 2002

6. ANSI/TIA-942 Telecommunications Infrastructure Standard for Data Centers, 2005

7. NFPA 70 – National Electric Code, 2008

1.4 SUBMITTALS

A. Provide product data for the following:

1. Manufacturers cut sheets, specifications and installation instructions for all products (submit with bid).

PART 2 – PRODUCTS

2.1 EQUIPMENT RACKS

A. Free Standing Relay Racks (Standard Rack)

1. Racks shall be manufactured from aluminum extrusion.

2. Each rack shall have two L-shaped top angles, two L-shaped base angles and two C-shaped equipment-mounting channels. The rack shall assemble with nut and bolt hardware. The base angles shall be pre-punched for attachment to the floor.

3. Equipment mounting channels shall be 3” (76 mm) deep and punched on the front and rear flange with the EIA-310-D Universal hole pattern, 1-3/4” (44.45 mm) rack-mount spaces (U), to provide 45U, 52U or 58U for equipment. Each mounting space (U) shall be marked and numbered on the mounting channel.

4. When assembled with top and bottom angles, equipment-mounting channels shall be spaced to allow attachment of 19” EIA rack-mount equipment. Equipment attachment points shall be threaded with 12-24 roll-formed threads. The rack shall include assembly and equipment-mounting hardware. Racks shall include 50 each combination pan head, pilot point mounting screws.

5. The assembled rack shall measure 7’ (2.1 m)/84” (2133 mm) high, 8’ (2.4 m)/96” (2438 mm) high or 9’ (2.7 m)/108” (2743 mm) high; 20.3” (515.9 mm) wide and 15” (381.0 mm) deep. The sides (webs) of the equipment-mounting channels shall be punched to allow attachment of vertical cable managers along the sides of the rack or for rack-to-rack baying.

6. Assembly hardware shall electrically bond the top angles, side channels and base angles together when assembled, and there shall be a masked ground attachment point with 1/4-20 threaded studs spaced 5/8” apart on the inside of the side channel to attach a ground lug allowing easy attachment to the Telecommunications Ground.

7. The rack shall be rated for 1,000 lb (453.6 kg) of equipment.

8. The rack shall be UL and cUL Listed as a Communications Circuit Accessory, DUXR and DUXR7 category, file number 140851.

9. Finish shall be either clear grained aluminum or epoxy-polyester hybrid powder coat in the color as specified below.

10. Design Make shall be:
    Chatsworth Products, Inc. (CPI),
    Standard Rack

    Part Number 55053-703, Standard Rack, 7'H (2.1 m) x 20.3"W (515.9 mm) x 15"D (381.0 mm), 45U x 19"EIA, Black, UL Listed.
    Part Number 55053-E03, Standard Rack, 7'H (2.1 m) x 20.3"W (515.9 mm) x 15"D (381.0 mm), 45U x 19"EIA, Glacier White, UL Listed.

    Part Number 40605-005, Equipment Mounting Screws, #12-24, 50 pack, Black.
    Part Number 40604-003, Rack Installation Kit, Concrete Slab, Zinc.
    Part Number 40607-001, Rack Installation kit, Wood Floor, Zinc

11. Design Make shall be:
    Chatsworth Products, Inc. (CPI),
    Cabinet

    Part Number GF-2C220-EA, Cabinet, 4SLSQ,800WX1000DX45U,PM/DPM,GW, Black, UL Listed.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Relay Racks

1. Assemble relay racks according to manufacturer's instructions. Verify that equipment mounting rails are sized properly for rack-mount equipment before attaching the rack to the floor.
2. All racks must be attached to the floor in four places using appropriate floor mounting anchors. When placed over a raised floor, threaded rods should pass through the raised floor tile and be secured in the structural floor below. (Use CPI Part Number 40604-003 for concrete slab floors or 40607-001 wood floors. Raised floor support kits are also available.)
3. Racks shall be grounded to the TGB using appropriate hardware provided by the contractor. The ground will meet local code requirements and will be approved by the Authority Having Jurisdiction (AHJ).
4. In seismic areas, the rack should have additional bracing as required by building codes and the recommendations of a licensed structural engineer.
5. Ladder rack may be attached to the top of the rack to deliver cables to the rack. The rack shall not be drilled to attach ladder rack. Use appropriate hardware from the ladder rack manufacturer.
6. The equipment load will be evenly distributed and uniform on the rack. Place large and heavy equipment towards the bottom of the rack. Secure all equipment to the rack with equipment mounting screws. In seismic areas, secure equipment to shelves with additional bracing.

Section 27 11 23

Communications Cable Management and Ladder Rack

PART 1 – GENERAL

1.3 WORK INCLUDED

B. Provide all labor, materials, and equipment for the complete installation of work called for in the contract documents.

1.4 SCOPE OF WORK

B. This section includes the minimum requirements for the equipment and cable installations in telecommunications rooms.

B. Included in this section are the minimum composition requirements and installation methods for the following:

3. Ladder Rack.

1.3 QUALITY ASSURANCE

D. All cable and equipment shall be installed in a neat and workmanlike manner. All methods of construction that are not specifically described or indicated in the contract documents shall be subject to the control and approval of the owner or owner representative.

E. Equipment and materials shall be of the quality and manufacture indicated. The equipment specified is based upon the acceptable manufacturers listed. Where “approved equal” is stated or a substitution is requested, equipment shall be equivalent in every way to that of the equipment specified. All substitutions are subject to the control and approval of the owner or the owner representative.

F. Strictly adhere to all Building Industry Consulting Service International (BICSI), Electronic Industries Alliance (EIA) and Telecommunications Industry Association (TIA) recommended installation practices when installing communications/data cabling.

G. Material and work specified herein shall comply with the applicable requirements of:

8. TIA – 569-B Commercial Building Standard for Telecommunications Pathways and Spaces, 2004

9. ANSI/TIA – 568-C Commercial Building Telecommunications Cabling Standard, 2009

10. ANSI/NECA/BICSI 568-2006 – Standard for Installing Commercial Building Telecommunications Cabling

11. TIA – 606-A Administration Standard for Commercial Telecommunications Infrastructure, 2007

12. ANSI-J-STD – 607-A Joint Standard for Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications, 2002

13. ANSI/TIA-942 Telecommunications Infrastructure Standard for Data Centers, 2005

14. NFPA 70 – National Electric Code, 2008

15. NEMA – VE 1 – Metal Cable Tray Systems, 2009

16. NEMA – VE 2 – Metal Cable Tray Installation Guidelines, 2006

1.4 SUBMITTALS

B. Provide product data for the following:

1. Manufacturers data/cut sheets, product drawing/specifications and installation instructions for all products (submit with bid).

PART 2 – PRODUCTS

2.4 LADDER RACK, SUPPORTS, AND ACCESSORIES

A. Ladder Rack (Universal Cable Runway)

1. Ladder rack shall be manufactured from 3/8” (9.5 mm) wide by 1-1/2” (38 mm) high tubular steel with .065” (1.65 mm) wall thickness.

2. Ladder rack (side stringers) will be 9’-11½ “ (3.0 m) long. Cross members will be welded in between stringers on 12” (300 mm) intervals/centers beginning 5-3/4” (146 mm) from one end so that there are 10 cross members per ladder rack. There will be 10-1/2” (267 mm) of open space in between each cross member.

3. Ladder rack will be delivered individually boxed, and available in the width(s) specified below.

4. Ladder rack will be UL Classified for suitability as an equipment grounding conductor only (the installer must remove paint or use ground straps at splices and intersections)

5. Finish shall be epoxy-polyester hybrid powder coat (paint) in the color(s) specified below.

6. Design Make:
Chatsworth Products, Inc. (CPI),
Universal Cable Runway:

Part Number 10250-704, Universal Cable Runway, 4” (100 mm) Wide, Black.
Part Number 10250-706, Universal Cable Runway, 6” (150 mm) Wide, Black.
Part Number 10250-709, Universal Cable Runway, 9” (230 mm) Wide, Black.
Part Number 10250-712, Universal Cable Runway, 12” (300 mm) Wide, Black.
Part Number 10250-715, Universal Cable Runway, 15” (380 mm) Wide, Black.
Part Number 10250-718, Universal Cable Runway, 18” (460 mm) Wide, Black.
Part Number 10250-724, Universal Cable Runway, 24” (610 mm) Wide, Black.
Part Number 10250-731, Universal Cable Runway, 30” (760 mm) Wide, Black.
Part Number 10250-737, Universal Cable Runway, 36” (910 mm) Wide, Black

B. Horizontal-To-Vertical 90° Turns (Cable Runway Inside Radius Bend)

1. Horizontal-to-vertical 90° turns shall be manufactured from 3/8” (9.5 mm) wide by 1-1/2” (38 mm) high tubular steel with .065” (1.65 mm) wall thickness.

2. Stringers (sides) will be formed in a 90° arc with a 12-1/2” (317.5 mm) outside radius. Cross members will be welded in between stringers on approximate 23° increments so that there are 3 cross members per turn. The welded assembly will create a smooth 90° horizontal-to-vertical turn.

3. Horizontal-to-vertical 90° turns will be available in the width(s) specified below.

4. Finish shall be epoxy-polyester hybrid powder coat (paint) in the color(s) specified below.

5. Design Make:
Chatsworth Products, Inc. (CPI),
Cable Runway Inside Radius Bend:

Part Number 10724-706, Inside Radius Bend, 6” (150 mm) Wide, Black.
Part Number 10724-709, Inside Radius Bend, 9” (230 mm) Wide, Black.
Part Number 10724-712, Inside Radius Bend, 12” (300 mm) Wide, Black.
Part Number 10724-715, Inside Radius Bend, 15” (380 mm) Wide, Black.
Part Number 10724-718, Inside Radius Bend, 18” (460 mm) Wide, Black.
Part Number 10724-720, Inside Radius Bend, 20” (510 mm) Wide, Black.
Part Number 10724-724, Inside Radius Bend, 24” (610 mm) Wide, Black.

C. Corner Brackets (Cable Runway Corner Bracket)

1. Corner brackets shall be manufactured from 3/8” (9.5 mm) wide by 1-1/2” (38 mm) high tubular steel with .065” (1.65 mm) wall thickness.

2. The inside stringers of the corner bracket will be formed at 90° with a small chamfer at the vertex. The outside stringer of the corner bracket will be formed in a 90° arc that is either 15” (380 mm) or 24” (610 mm) in radius. A single cross member will connect the chamfered portion of the inside stringer to the outside

stringer. The welded assembly will create a smooth 90° turn within the L-shaped corner created by two intersecting ladder racks.

3. Corner brackets will be available in the size(s) specified below. Installation hardware will be included with the corner bracket. Corner bracket installation hardware does not include the junction splice kit required to form the L-shaped intersection between two ladder racks.

4. Finish shall be epoxy-polyester hybrid powder coat (paint) in the color specified below.

5. Design Make:
Chatsworth Products, Inc. (CPI),
Cable Runway Corner Bracket:

Part Number 11959-715, Corner Bracket, 15" (380 mm) Radius, Black.
Part Number 11959-724, Corner Bracket, 24" (610 mm) Radius, Black.

D. Ladder Rack Splices

1. Splice kits will provide a method of mechanically connecting ladder rack sections and turns together end-to-end or side-to-end to form a continuous pathway for cables.

2. Grounding kits will provide a method of bonding ladder rack sections and turns together that is independent of the pathway splices. The grounding kit should be constructed of UL Listed components. The preferred solution is a #6 AWG green insulated stranded copper conductor connected on both ends to ladder rack using two-hole compression lugs and stainless steel hardware.

3. An insulator bar kit will provide a means of electrically isolating individual ladder rack sections through an end-to-end splice separated with a non-conductive material. The preferred solution is a 3/8" (9.5 mm) wide by 1-1/2" (38 mm) high by 5-1/2" (140 mm) long insulator bar made of Delrin® (by DuPont, Delrin is a registered trademark of E.I. du Pont de Nemours and Company).

4. Splices (splice plates) will be manufactured from steel. Splice, grounding and insulator bar kits will include installation hardware.

5. Finish (of splice plates and hardware) shall be zinc plate in the color(s) specified below. Colors are applied as a chem. film over the zinc plate.

6. Design Make:
Chatsworth Products, Inc. (CPI),
Cable Runway Splices:

Part Number 11301-701, Butt-Splice Kit, Black.
Compression splice for end-to-end connections.

Part Number 11302-701, Junction-Splice Kit, Black.

Compression splice for T- or L-connections.

Part Number 12061-001, Grounding Kit, Zinc.
Bolted jumper that electrically bonds cable runway sections.

Part Number 10842-001, Insulator Bar Kit, White.
Compression splice for end-to-end connection that electrically isolates cable runway sections.

E. Ladder Rack Supports

1. Supports will be sized to match the width of the ladder rack that is supported. Some supports will work with multiple or all widths of ladder rack.

2. Each support will include a means of mechanically securing ladder rack to the support.

3. Supports will be manufactured from steel or aluminum.

4. Finish shall be epoxy-polyester hybrid powder coat (paint) in the color(s) specified below or zinc plate with a gold chem. finish specified gold. Included hardware shall be zinc plated with a gold chem. finish.

5. Design Make:
Chatsworth Products, Inc. (CPI),
Cable Runway Supports:

Part Number 11312-706, Triangular Support Bracket, For 4”-6” (100 mm – 150 mm) Wide Cable Runway (Ladder Rack), 100 lb (45.4 kg) Capacity, Aluminum, Black.
Part Number 11312-712, Triangular Support Bracket, For 6”-12” (150 mm – 300 mm) Wide Cable Runway (Ladder Rack), 100 lb (45.4 kg) Capacity, Aluminum, Black.
Part Number 11312-718, Triangular Support Bracket, For 12”-18” (300 mm – 460 mm) Wide Cable Runway (Ladder Rack), 100 lb (45.4 kg) Capacity, Aluminum, Black.
Wall support for side of cable runway. Installation requires (3) 5/16” or 8 mm lag bolts and (3) flat washers or concrete wall hardware (ordered separately).

Part Number 11746-712, Triangular Support Bracket, For 6” (150 mm) or 12” (300 mm) Wide Cable Runway (Ladder Rack), 400 lb (181.4 kg) Capacity, Steel, Black.
Part Number 11746-718, Triangular Support Bracket, For 18” (460 mm) Wide Cable Runway (Ladder Rack), 400 lb (181.4 kg) Capacity, Steel, Black.
Part Number 11746-724, Triangular Support Bracket, For 24” (610 mm) Wide Cable Runway (Ladder Rack), 400 lb (181.4 kg) Capacity, Steel, Black.
Wall support for side of cable runway. Installation requires (3) 5/16” or 8 mm lag bolts and (3) flat washers or concrete wall hardware (ordered separately).

Part Number 11421-704, Wall Angle Support Kit, For 4” (100 mm) Wide Cable Runway (Ladder Rack), Steel, Black.
Part Number 11421-706, Wall Angle Support Kit, For 6” (150 mm) Wide Cable Runway (Ladder Rack), Steel, Black.
Part Number 11421-709, Wall Angle Support Kit, For 9” (230 mm) Wide Cable Runway (Ladder Rack), Steel, Black.
Part Number 11421-712, Wall Angle Support Kit, For 12” (300 mm) Wide Cable Runway (Ladder Rack), Steel, Black.
Part Number 11421-715, Wall Angle Support Kit, For 15” (380 mm) Wide Cable Runway (Ladder Rack), Steel, Black.
Part Number 11421-718, Wall Angle Support Kit, For 18” (460 mm) Wide Cable Runway (Ladder Rack), Steel, Black.
Part Number 11421-720, Wall Angle Support Kit, For 20” (510 mm) Wide Cable Runway (Ladder Rack), Steel, Black.
Part Number 11421-724, Wall Angle Support Kit, For 24” (610 mm) Wide Cable Runway (Ladder Rack), Steel, Black.
Wall support for end of cable runway. Installation requires (2) 5/16” or 8 mm lag bolts and (2) flat washers or concrete wall hardware (ordered separately).

Part Number 11309-001, Foot Kit, Steel, Gold.
Floor support for end of cable runway. (2) L-shaped bracket and (1) butt-splice kit. Installation requires (2) 3/8” or 10 mm lag bolts and (2) flat washers or concrete wall hardware (ordered separately).

Part Number 11241-712, Adjustable Floor Support Channel, For 12” (300 mm) Wide Cable Runway (Ladder Rack), 3” to 8” (80 mm to 200 mm) High, Steel, Black.
Part Number 11241-715, Adjustable Floor Support Channel, For 15” (380 mm) Wide Cable Runway (Ladder Rack), 3” to 8” (80 mm to 200 mm) High, Steel, Black.
Part Number 11241-718, Adjustable Floor Support Channel, For 18” (460 mm) Wide Cable Runway (Ladder Rack), 3” to 8” (80 mm to 200 mm) High, Steel, Black.
Floor support for the bottom of cable runway. 1 pair of channels (2 supports). Includes 5/8” threaded rod and floor installation hardware. Requires accessory anchor installation tool (P/N 06003-001) or substitut) M16 threaded rod, (2) lock washers, (4) hex nuts and floor installation hardware (ordered separately).

Part Number 11310-001, Threaded Ceiling Kit, Includes 3/8” Diameter x 6’ L Rod, Steel, Gold.
Part Number 11310-003, Threaded Ceiling Kit, Includes 5/8” Diameter x 6’ L Rod, Steel, Gold.
Part Number 11310-093, Threaded Ceiling Kit, Includes M10 Diameter x 2 m L Rod, Steel, Gold.
Part Number 11310-094, Threaded Ceiling Kit, Includes M16 Diameter x 2 m L Rod, Steel, Gold.
Ceiling support for the side of cable runway. Kit includes (1) threaded rod, hardware and connectors for cable runway and a concrete ceiling. Use in pairs at each point of support. Ceiling installation hardware not included.

Part Number 12362-706, Center Support Kit, For 6” (150 mm) Wide Cable Runway (Ladder Rack), Steel, Black.
Part Number 12362-712, Center Support Kit, For 12” (300 mm) Wide Cable Runway (Ladder Rack), Steel, Black.
Part Number 12362-715, Center Support Kit, For 15” (380 mm) Wide Cable Runway (Ladder Rack), Steel, Black.
Part Number 12362-718, Center Support Kit, For 18” (460 mm) Wide Cable Runway (Ladder Rack), Steel, Black.
Part Number 12362-724, Center Support Kit, For 24” (610 mm) Wide Cable Runway (Ladder Rack), Steel, Black.
Center Support Kit is used with a single threaded rod to support cable runway from the bottom to the ceiling. One support is included per kit. Includes 5/8” Hex Nuts and Washers. Requires 5/8” rod and ceiling installation hardware or M16 rod, (2) hex nuts, (1 lock washer and ceiling installation hardware (ordered separately).

Part Number 10595-704, Rack-To-Runway Mounting Plate, For 4” (100 mm) Wide Cable Runway (Ladder Rack), for Standard and Universal Racks with 3” (80 mm) Deep Equipment Mounting Channels, Steel, Black.
Part Number 10595-708, Rack-To-Runway Mounting Plate, For 5” to 8” (130 mm to 200 mm) Wide Cable Runway (Ladder Rack), for Standard and Universal Racks with 3” (80 mm) Deep Equipment Mounting Channels, Steel, Black.
Part Number 10595-712, Rack-To-Runway Mounting Plate, For 9” to 12” (230 mm to 300 mm) Wide Cable Runway (Ladder Rack), for Standard and Universal Racks with 3” (80 mm) Deep Equipment Mounting Channels, Steel, Black.
Part Number 10595-718, Rack-To-Runway Mounting Plate, For 15” to 18” (380 mm to 460 mm) Wide Cable Runway (Ladder Rack), for Standard and Universal Racks with 3” (80 mm) Deep Equipment Mounting Channels, Steel, Black.
Part Number 12408-724, Rack-To-Runway Mounting Plate, For 20” (510 mm) and 24” (610 mm) Wide Cable Runway (Ladder Rack), for Standard and Universal Racks with 3” (80 mm) Deep Equipment Mounting Channels, Aluminum, Black.
Rack-To-Runway Mounting Plate attaches cable runway to the top of 2-post freestanding racks in parallel or perpendicular orientation. Includes J-bolt installation hardware for 1-1/2” (38 mm) High cable runway and rack top angles. CPI recommends use with Cable Runway Elevation Kit.

Part Number 12121-709, Rack-To-Runway Mounting Plate, For 5” to 9” (130 mm to 230 mm) Wide Cable Runway (Ladder Rack), For Standard Rack with 6” (150 mm) Deep Equipment Mounting Channels, Steel, Black.
Part Number 12121-712, Rack-To-Runway Mounting Plate, For 9” to 12” (230 mm to 300 mm) Wide Cable Runway (Ladder Rack), for Standard Rack with 6” (150 mm) Deep Equipment Mounting Channels, Steel, Black.
Part Number 12121-718, Rack-To-Runway Mounting Plate, For 15” to 18” (380 mm to 460 mm) Wide Cable Runway (Ladder Rack), for Standard Rack with 6” (150 mm) Deep Equipment Mounting Channels, Steel, Black.
Part Number 12409-724, Rack-To-Runway Mounting Plate, For 20” (510 mm) and 24” (610 mm) Wide Cable Runway (Ladder Rack), for Standard Rack with 6” (150 mm) Deep Equipment Mounting Channels, Aluminum, Black.
Rack-To-Runway Mounting Plate attaches cable runway to the top of 2-post freestanding racks in parallel or perpendicular orientation. Includes J-bolt

installation hardware for 1-1/2" (38 mm) high cable runway and rack top angles. CPI recommends use with Cable Runway Elevation Kit.

Part Number 12730-704, Rack-To-Runway Mounting Plate with Bracket, For 4" (100 mm) Wide Cable Runway (Ladder Rack), for Standard and Universal Racks with 3" (80 mm) Deep Equipment Mounting Channels, Steel, Black.
Part Number 12730-708, Rack-To-Runway Mounting Plate with Bracket, For 5" to 8" (130 mm to 200 mm) Wide Cable Runway (Ladder Rack), for Standard and Universal Racks with 3" (80 mm) Deep Equipment Mounting Channels, Steel, Black.
Part Number 12730-712, Rack-To-Runway Mounting Plate with Bracket, For 9" to 12" (230 mm to 300 mm) Wide, for Standard and Universal Racks with 3" (80 mm) Deep Equipment Mounting Channels, Steel, Black.
Part Number 12730-718, Rack-To-Runway Mounting Plate with Bracket, For 15" to 18" (380 mm to 460 mm) Wide, for Standard and Universal Racks with 3" (80 mm) Deep Equipment Mounting Channels, Steel, Black.
Part Number 13730-724, Rack-To-Runway Mounting Plate with Bracket, For 20" (510 mm) and 24" (610 mm) Wide, for Standard and Universal Racks with 3" (80 mm) Deep Equipment Mounting Channels, Aluminum, Black.
Rack-To-Runway Mounting Plate with Bracket attaches cable runway to the top of 2-post freestanding racks in parallel or perpendicular orientation. Includes U-shaped rack bracket and installation hardware for 1-1/2" (38 mm) High Cable Runway and rack top angles. CPI recommends use with Cable Runway Elevation Kit.

Part Number 12731-709, Rack-To-Runway Mounting Plate with Bracket, For 5" to 9" (130 mm to 230 mm) Wide Cable Runway (Ladder Rack), for Standard Rack with 6" (150 mm) Deep Equipment Mounting Channels, Steel, Black.
Part Number 12731-712, Rack-To-Runway Mounting Plate with Bracket, For 9" to 12" (230 mm to 300 mm) Wide Cable Runway (Ladder Rack), for Standard Rack with 6" (150 mm) Deep Equipment Mounting Channels, Steel, Black.
Part Number 12731-718, Rack-To-Runway Mounting Plate with Bracket, For 15" to 18" (380 mm to 460 mm) Wide Cable Runway (Ladder Rack), for Standard Rack with 6" (150 mm) Deep Equipment Mounting Channels, Steel, Black.
Part Number 12731-724, Rack-To-Runway Mounting Plate with Bracket, For 20" (510 mm) and 24" (610 mm) Wide Cable Runway (Ladder Rack), for Standard Rack with 6" (150 mm) Deep Equipment Mounting Channels, Aluminum, Black.
Rack-To-Runway Mounting Plate with Bracket attaches cable runway to the top of 2-post freestanding racks in parallel or perpendicular orientation. Includes U-shaped rack bracket and installation hardware for 1-1/2" (38 mm) High Cable Runway and rack top angles. CPI recommends use with Cable Runway Elevation Kit.

Part Number 10506-102, Cable Runway Elevation Kit, 2" (50 mm), 2-1/2" (64 mm) or 3" (80 mm) High, for Racks, Steel, Gray.
Part Number 10506-202, Cable Runway Elevation Kit, 2" (50 mm), 2-1/2" (64 mm) or 3" (80 mm) High, for Racks, Steel, Computer White.
Part Number 10506-702, Cable Runway Elevation Kit, 2" (50 mm), 2-1/2" (64 mm) or 3" (80 mm) High, for Racks, Steel, Black.

Part Number 10506-106, Cable Runway Elevation Kit, 4” (100 mm), 5” (130 mm) or 6” (150 mm) High, for Racks, Steel, Gray.
Part Number 10506-206, Cable Runway Elevation Kit, 4” (100 mm), 5” (130 mm) or 6” (150 mm) High, for Racks, Steel, Computer White.
Part Number 10506-706, Cable Runway Elevation Kit, 4” (100 mm), 5” (130 mm) or 6” (150 mm) High, for Racks, Steel, Black.

Part Number 10506-112, Cable Runway Elevation Kit, 2” (50 mm), 2-1/2” (64 mm) or 3” (80 mm) High, for Cabinets, Steel, Gray.
Part Number 10506-212, Cable Runway Elevation Kit, 2” (50 mm), 2-1/2” (64 mm) or 3” (80 mm) High, for Cabinets, Steel, Computer White.
Part Number 10506-712, Cable Runway Elevation Kit, 2” (50 mm), 2-1/2” (64 mm) or 3” (80 mm) High, for Cabinets, Steel, Black.

Part Number 10506-116, Cable Runway Elevation Kit, 4” (100 mm), 5” (130 mm) or 6” (150 mm) High, for Cabinets, Steel, Gray.
Part Number 10506-216, Cable Runway Elevation Kit, 4” (100 mm), 5” (130 mm) or 6” (150 mm) High, for Cabinets, Steel, Computer White.
Part Number 10506-716, Cable Runway Elevation Kit, 4” (100 mm), 5” (130 mm) or 6” (150 mm) High, for Cabinets, Steel, Black.
Cable Runway Elevation Kit are L-shaped supports that elevate cable runway 2” (50 mm), 2-1/2” (64 mm), 3” (80 mm) or 4” (100 mm) , 5” (130 mm), 6” (150 mm) above the rack or cabinet. May also be used to support cable runway vertically against a wall with a standoff from the wall. Kits for racks must be used with a Rack-To-Runway Mounting Plate. Includes installation hardware for Rack-to-Runway Mounting Plates and Cabinets. Order installation hardware for wall separately.

Part Number 31470-712, Cable Runway Standoff Kit, 12” (300 mm) High, Steel, Black.
Support a second tier of cable runway 12” (300 mm) above the first tier of cable runway with Cable Runway Standoff Kit. Includes one pair of supports and installation hardware.

Part Number 10608-001, Vertical Wall Brackets, 1 pair, Steel, Gold.
Attach cable runway to the wall or floor with no standoff. 1/4” or M6 installation hardware not included.

Part Number 10684-701, Tall Pipe Stand, 2” (50 mm) Diameter x 79” (2010 mm) High, Black. Use for 7’ (2.1 m) high supports.
Part Number 10684-702, Tall Pipe Stand, 2” (50 mm) Diameter x 85” (2160 mm) High, Black. Use for 7’-6” (2.3 m) high supports.
Part Number 10684-703, Tall Pipe Stand, 2” (50 mm) Diameter x 91” (2310 mm) High, Black. Use for 8’ (2.4 m) high supports.
Part Number 10684-704, Tall Pipe Stand, 2” (50 mm) Diameter x 103” (2620 mm) High, Black. Use for 9’ (2.7 m) high supports.
Pipe stands include 1/4“ concrete floor installation hardware. Use with cable runway center support kit and 5/8-11 threaded rod.

Part Number 11235-701, Adjustable Floor Support Stands, 5” to 6” (130 mm to 150 mm) High, 1 pair, Black.
Part Number 11236-701, Adjustable Floor Support Stands, 6” to 8” (150 mm to 200 mm) High, 1 pair, Black.
Part Number 11237-701, Adjustable Floor Support Stands, 8” to 10” (200 mm to 300 mm) High, 1 pair, Black.
Adjustable floor support stands include framing bar clamps, threaded rod and hardware. Floor installation hardware is not included. Order 1/4“ floor installation hardware separately.

F. Ladder Rack Accessories

1. Cable straps used for attaching cable bundles to the ladder rack cross members must be reusable with a hook and loop-style closure, at least 3/4” (19 mm) wide, and sized for cable bundles that are 2” (50 mm), 3” (80 mm) or 4” (100 mm) in diameter.

2. Cable retaining posts used to keep cable from falling off of the side of the ladder rack shall be manufactured from 1” (25 mm) by 1/2” (12.7 mm) tubular steel with .065” (1.65 mm) wall thickness. Cable retaining posts will be 8” (200 mm) high and will attach to the side stringer of the ladder rack with included hardware. The top of the cable retaining posts will be fitted with a rubberized end cap to protect cables.

3. End caps used to cover the ends of ladder rack will be manufactured from a black fire-retardant rubberized material. End caps will be sized for 3/8” (9.5 mm) wide by 1-1/2” (38 mm) high side stingers and will be sold in pairs.

4. End closing kits used to cover the end of ladder rack will be manufactured from 3/8” (9.5 mm) wide by 1-1/2” (38 mm) high tubular steel with .065” (1.65 mm) wall thickness. Kits will consist of a bar cut to match the width of the ladder rack and the hardware required to attach the bar to the end of a length of ladder rack.

5. Radius drops used to create a radius to form cables over as the cables exit or enter the ladder rack will be manufactured from aluminum extrusion. The extrusion will be formed in a 90° arc with a minimum bend radius of 3” (75 mm). Radius drops will attach to either the side stringer or the cross member of the ladder rack using a clevis pin. Radius drops will include 1-1/2” (38 mm) high cable spools that attach to the top of the radius drop to guide cables.

6. Movable cross members used to support cross member radius drops in between welded cross members on ladder rack will be manufactured from 3/8” (9.5 mm) by 1-1/2” (38 mm) aluminum bar. Movable cross members will attach to ladder rack at the side stringers with included hardware so that the location of the movable cross member can be adjusted. Moveable cross member will support a cross member radius drop.

7. Cable spools used to separate ladder rack into multiple cable pathways will be made from a black flame retardant ABS. Cable spools will attach to the cross members with a clip that allows the width of the ladder rack to be divided into any

proportion. The spools will be 3.94” (100 mm) tall, with a 1.94” (49 mm) diameter top cap, and a body that tapers from .88” (22 mm) diameter at the top to .62” (16 mm) diameter at the bottom.

8. Auxiliary support brackets used to support cables that should be physically separated from the cables in the ladder rack will be made from 1/8” (3 mm) by 1” (25 mm) steel bar. The bracket will be L-shaped and will attach to the side stringer of the ladder rack. The bracket will hang below the ladder rack a minimum of 4” (100 mm). The bracket support surface will be 4” (100 mm) long. The bracket will be zinc plated with a gold chem. finish.

9. Touch-up paint used on ladder rack and ladder rack system components will be color-matched to the finish on the ladder rack or component. A spray on and brush on option will be available.

10. Unless otherwise noted, finish on all metal components shall be epoxy-polyester hybrid powder coat (paint) in the color(s) specified below. Hardware will be zinc plated with a gold chem. finish.

11. Design Make:
Chatsworth Products, Inc. (CPI),
Cable Runway Accessories:

Part Number 02006-203, Saf-T-Grip Reusable Cable Management Straps, Open Loop Series, 3/4” (19 mm) Wide by 6” (150 mm) Long for 2” (50 mm) Diameter Cable Bundles, Package of 25, Royal Blue.
Part Number 02009-203, Saf-T-Grip Reusable Cable Management Straps, Open Loop Series, 3/4” (19 mm) Wide by 9” (230 mm) Long for 3” (80 mm) Diameter Cable Bundles, Package of 25, Royal Blue.
Part Number 02012-203, Saf-T-Grip Reusable Cable Management Straps, Open Loop Series, 3/4” (19 mm) Wide by 12” (300 mm) Long for 4” (100 mm) Diameter Cable Bundles, Package of 25, Royal Blue.

Part Number 05006-203, Saf-T-Grip Reusable Cable Management Straps, End Grommet & Buckle Series, 3/4” (19 mm) Wide by 6” (150 mm) Long for 2” (50 mm) Diameter Cable Bundles, Package of 25, Royal Blue.
Part Number 05009-203, Saf-T-Grip Reusable Cable Management Straps, End Grommet & Buckle Series, 3/4” (19 mm) Wide by 9” (230 mm) Long for 3” (80 mm) Diameter Cable Bundles, Package of 25, Royal Blue.
Part Number 05012-203, Saf-T-Grip Reusable Cable Management Straps, End Grommet & Buckle Series, 3/4” (19 mm) Wide by 12” (300 mm) Long for 4” (100 mm) Diameter Cable Bundles, Package of 25, Royal Blue.

Part Number 10596-108, Cable Retaining Post, 8” (200 mm) High, Gray.
Part Number 10596-208, Cable Retaining Post, 8” (200 mm) High, Computer White.
Part Number 10596-708, Cable Retaining Post, 8” (200 mm) High, Black.

Part Number 10642-001, Cable Runway Protective End Caps, 1 Pair, Black.

Part Number 11700-704, End Closing Kit, For 4” (100 mm) Wide Cable Runway (Ladder Rack), Black.
Part Number 11700-706, End Closing Kit, For 6” (150 mm) Wide Cable Runway (Ladder Rack), Black.
Part Number 11700-709, End Closing Kit, For 9” (230 mm) Wide Cable Runway (Ladder Rack), Black.
Part Number 11700-712, End Closing Kit, For 12” (300 mm) Wide Cable Runway (Ladder Rack), Black.
Part Number 11700-715, End Closing Kit, For 15” (380 mm) Wide Cable Runway (Ladder Rack), Black.
Part Number 11700-718, End Closing Kit, For 18” (460 mm) Wide Cable Runway (Ladder Rack), Black.
Part Number 11700-720, End Closing Kit, For 20” (510 mm) Wide Cable Runway (Ladder Rack), Black.
Part Number 11700-724, End Closing Kit, For 24” (610 mm) Wide Cable Runway (Ladder Rack), Black.
End Closing Kit includes installation hardware - a Gold Junction Splice Kit.

Part Number 12100-706, Cross Member Radius Drop, 5” (130 mm) Wide, Black. . Fits 6” (150 mm) Wide Cable Runway (Ladder Rack).
Part Number 12100-709, Cross Member Radius Drop, 8” (200 mm) Wide, Black. Fits 9” (230 mm) Wide Cable Runway (Ladder Rack).
Part Number 12100-712, Cross Member Radius Drop, 11” (280 mm) Wide, Black. Fits 12” (300 mm) Wide Cable Runway (Ladder Rack).
Part Number 12100-718, Cross Member Radius Drop, 17” (430 mm) Wide, Black. Fits 18” (460 mm) Wide Cable Runway (Ladder Rack),

Part Number 12101-701, Side Stringer Radius Drop, Universal Cable Runway, Black.

Part Number 12115-709, Movable Cross Member, For 9” (230 mm) Wide Cable Runway and 5” (130 mm) Wide Radius Drop, Black.
Part Number 12115-712, Movable Cross Member, For 12” (300 mm) Wide Cable Runway and 8” (200 mm) Wide Radius Drop, Black.
Part Number 12115-718, Movable Cross Member, For 18” (460 mm) Wide Cable Runway and 11” (280 mm) Wide Radius Drop, Black.

Part Number 13392-711, Cable Runway Dividers, Package of 5, Black.
Part Number 13392-712, Cable Runway Dividers, Package of 25, Black.

Part Number 11268-001, L-Bracket, 4” (100 mm) High x 4” (100 mm) Long, Gold over Zinc.

Part Number 25400-700, Touch-Up Paint in Spray Can, Black.
Paint in spray cans cannot be shipped by air.

Part Number 25401-700, Touch-Up Paint in 1oz. Bottle, Black.

G. Miscellaneous Hardware

1. Design Make:
Chatsworth Products, Inc. (CPI),
Miscellaneous Hardware:

Part Number 11440-001, Threaded Drop Rod, 3/8-16 UNC-2A rod, 6’ Long, Gold.
Part Number 11440-002, Threaded Drop Rod, 5/8-11 UNC-2A rod, 6’ Long, Gold.
Part Number 11440-003, Threaded Drop Rod, 3/8-16 UNC-2A rod, 12’ Long, Gold.
Part Number 11440-004, Threaded Drop Rod, 5/8-11 UNC-2A rod, 12’ Long, Gold.
Part Number 11440-005, Threaded Drop Rod, 5/8-11 UNC-2A rod, 8’ Long, Gold.
Part Number 11440-006, Threaded Drop Rod, 5/8-11 UNC-2A rod, 4’ Long, Gold.
Part Number 11440-007, Threaded Drop Rod, 5/8-11 UNC-2A rod, 6” Long, Gold.
Part Number 11440-008, Threaded Drop Rod, 5/8-11 UNC-2A rod, 8” Long, Gold.
Part Number 11440-009, Threaded Drop Rod, 5/8-11 UNC-2A rod, 5.5” Long, Gold.
Part Number 11440-012, Threaded Drop Rod, 5/8-11 UNC-2A rod, 1’ Long, Gold.
Part Number 11440-024, Threaded Drop Rod, 5/8-11 UNC-2A rod, 2’ Long, Gold.
Part Number 11440-036, Threaded Drop Rod, 5/8-11 UNC-2A rod, 3’ Long, Gold.
Part Number 11440-091, Threaded Drop Rod, M10 x 1.5 Rod, 1 m Long, Gold
Part Number 11440-092, Threaded Drop Rod, M16 x 2 Rod, 2 m Long, Gold
Part Number 11440-093, Threaded Drop Rod, M10 x 1.5 Rod, 2 m Long, Gold
Part Number 11440-094, Threaded Drop Rod, M16 x 2 Rod, 2 m Long, Gold
Part Number 11440-095, Threaded Drop Rod, M10 x 1.5 Rod, 3 m Long, Gold
Part Number 11440-096, Threaded Drop Rod, M16 x 2 Rod, 3 m Long, Gold

Part Number 10697-001, Threaded Rod Coupling Kit, for 3/8-16 UNC-2A rods, Gold.
Part Number 10697-002, Threaded Rod Coupling Kit, for 5/8-11 UNC-2A rods, Gold.

Part Number 11085-001, Threaded Rod Cover, 10’ (3 m) Long, Plastic, Gray.

Part Number 10557-001, Threaded Rod I-Beam Clamp, for 3/8-16 UNC-2A rod, Gold.
Part Number 10557-003, Threaded Rod I-Beam Clamp, for 5/8-11 UNC-2A rod, Gold.

Part Number 11408-001, Cable Runway Support Bracket, for 3/8” or M10 drop rod and 1-1/2” (38 mm) High Cable Runway, Gold.
Part Number 11408-003, Cable Runway Support Bracket, for 5/8” or M16 drop rod and 1-1/2” (38 mm) High Cable Runway, Gold.

Part Number 11406-001, Ceiling Support Bracket, for 3/8” or M10 drop rod, Gold.
Part Number 11406-002, Ceiling Support Bracket, for 5/8” or M16 drop rod, Gold.

Part Number 10607-002, Cable Runway Slotted Support Bracket, for 3/8” or M10 drop rod and 1-1/2” (38 mm) High Cable Runway, Gold.
Part Number 10607-001, Cable Runway Slotted Support Bracket, for 5/8” or M16 drop rod and 1-1/2” (38 mm) High Cable Runway, Gold.

Part Number 10873-001, Slip-On Cable Runway Support Bracket, for 5/8” drop rod, Gold.

Part Number 03003-001, Slip-On Lock Nut, for 3/8-16 UNC-2A rod, Zinc plated.
Part Number 03003-002, Slip-On Lock Nut, for 5/8-11 UNC-2A rod, Zinc plated.

Part Number 20142-071, Hex Nut, 1/4-20, Gold.
Part Number 20142-081, Hex Nut, 5/16-18, Gold.
Part Number 20142-091, Hex Nut, 3/8-16, Gold.
Part Number 03001-001, Hex Nut, 1/2-13, Gold.
Part Number 20142-111, Hex Nut, 5/8-11, Gold.

Part Number 04003-002, Split Lock Washer, 1/4, Gold.
Part Number 20141-080, Split Lock Washer, 5/16, Gold.
Part Number 20142-090, Split Lock Washer, 3/8, Gold.
Part Number 20141-100, Split Lock Washer, 1/2, Gold.
Part Number 04003-001, Split Lock Washer, 5/8, Gold.

Part Number 04002-002, Washer, Type A Plain, 3/8, Gold.
Part Number 04002-001, Washer, Type A Plain, 5/8, Gold.

Part Number 02007-004, Hex Lag Screw, 1/4-10 x 2” Long, Gold
Part Number 02006-001, Hex Lag Screw, 1/2-6 x 2” Long, Gold.
Part Number 20098-832, Hex Lag Screw, 3/8-7 x 2” Long, Gold
Part Number 02006-002, Hex Lag Screw, 5/8-5 x 2” Long, Gold

Part Number 20067-001, Anchor, 3/8-16 x Expansion Shield, Zinc.
Part Number 06001-004, Anchor, 5/8-11 Multi-set, Zinc.
Part Number 06003-001, Anchor Setting Tool, for P/N 06001-004.

PART 3 – EXECUTION

3.1 INSTALLATION

B. Ladder Rack

1. Provide all components of the ladder rack system (ladder rack, turns, splices, supports, and accessories) from a single manufacturer.

2. Ladder rack shall be installed with side stringers facing down so that the ladder forms an inverted U-shape and so that welds between the stringers (sides) and cross members (middle) face away from cables.

3. Ladder rack shall be secured to the structural ceiling, building truss system, wall, floor or the tops of equipment racks and/or cabinets using the manufacturer's recommended supports and appropriate installation hardware and methods as defined by local code or the authority having jurisdiction (AHJ).

4. Ladder rack splices will be made in mid-span, not over a support, with the manufacturer's recommended splice hardware.

5. Ladder rack shall be supported every 5' (1.5 m) or less in accordance with TIA-569-B. Ladder rack shall be supported within 2' (0.6 m) of every splice and within 2' (0.6 m) on both/all sides of every intersection. Support ladder rack within 2' (0.6 m) on both sides of every change in elevation. Support ladder rack every 2' (0.6 m) when attached vertically to a wall.

6. Heavy-duty splices are recommended for 18" (460 mm) wide or wider ladder rack. Heavy-duty splices are required for any splice formed in the vertical orientation including changes in elevation formed using vertical-to-horizontal 90° turns or horizontal-to-vertical 90° turns. Use heavy-duty splices to secure all overhead turns to the overhead horizontal pathway(s).

7. When the pathway is overhead, ladder rack shall be installed with a minimum clearance of 12" (300 mm) above the ladder rack. Leave a minimum of 12" (300 mm) in between ladder rack and ceiling/building truss structure. Leave a minimum of 3" (75 mm) in between ladder rack and the tops of equipment racks and/or cabinets. Multiple tiers of ladder rack shall be installed with a minimum clearance of 12" (300 mm) in between each tier of ladder rack. When located above an acoustical drop ceiling, leave a minimum of 3" (75 mm) clearance between the top of the drop ceiling tiles and the bottom of the ladder rack.

8. When installed under a raised floor, ladder rack shall be installed with a minimum 3" (75 mm) clearance between the top of the ladder rack and the bottom of the floor tiles or floor system stringers, whichever is lower in elevation. Maintain a 3" (75 mm) clearance between ladder racks wherever ladder racks cross.

9. Within each telecommunications room, ladder rack should be bonded together, electrically continuous, and bonded to the TGB, unless otherwise noted in the specifications and contract documents. Ladder rack and turns shall be bonded across each splice with a bonding kit or with splices per the manufacturer's installation instructions. Ladder rack shall be bonded to the Telecommunications Grounding Busbar (TGB) using an approved ground lug on the ladder rack and a minimum #6 grounding wire or as recommended by the AHJ. Remove paint from the ladder rack where bonding/ground lugs or splices contact the ladder rack so that the lug or spice will contact bare metal. Use antioxidant joint compound in between the bare metal on the ladder rack and ground lug or splice. Use antioxidant joint compound in between the bus bar and the ground lug. Verify continuity through the bonds at splices and intersections between individual ladder rack sections and turns and through the bond to the TGB.

10. The quantity of cables within the ladder rack will not exceed a whole number value equal to 50% of the interior area of the ladder rack divided by the cross-sectional area of the cable. The interior area of ladder rack will be considered to be the width of the ladder rack multiplied by a height of 2” (50 mm), unless cable retaining posts are added to the ladder rack. The interior area of ladder rack equipped with cable retaining posts will be considered to be the width of the ladder rack multiplied by a height of 6” (150 mm). Actual cable fill for ladder rack that is not equipped with cable retaining posts will not exceed 2” (50 mm) in height. Actual cable fill for ladder rack equipped with cable retaining posts will not exceed 6” (150 mm) in height.

11. The combined weight of cables within the ladder rack will not exceed the stated load capacity of the ladder rack as stated in the manufacturer’s product specifications or load/design tables.

12. Cables (cable bundles) will be secured to the cross members of ladder rack with 3/4” (19 mm) wide reusable straps. Straps are not required when ladder rack is equipped with cable retaining posts.

13. Add 8” (200 mm) high cable retaining posts to the open sides of ladder rack when cable fill exceeds 2” (50 mm) in height or when cable bundles cannot be secured directly to the ladder rack cross members with a strap. Cable fill within any ladder rack should not exceed 6” (150 mm) in height.

14. When a single ladder rack supports different types of cable media, the cable media will be separated within the pathway by cable spools that attach to the cross members on the ladder rack. Treat each type of cable media and divided area of the ladder rack separately when determining cable fill limits.

15. Use a radius drop to guide cables wherever cable exits overhead ladder rack to access a rack, frame, cabinet or wall-mounted rack, cabinet or termination field. If necessary, provide a moveable cross member also to attach and align the radius drop in between the welded cross members of a ladder rack.

16. Cover the exposed ends of cable runway that do not terminate against a wall, the floor or the ceiling with end caps or an end closing kit.

17. Use auxiliary support brackets that attach to the side stringer of the ladder rack to support interconnect cabling (patch cords, equipment cords, jumper cords) that is routed between racks using the ladder rack. Auxiliary support brackets can be used to support other conductors that should be physically separated from cables within the ladder rack as defined by local code or the authority having jurisdiction (AHJ).

18. Whenever possible, maintain a 2’ (0.6 m) separation between ladder rack used for communications cables and pathways for other utilities or building services.

19. The installer will provide touch-up paint color-matched to the finish on the ladder rack and will correct any minor cosmetic damage (chips, small scratches, etc.) resulting from normal handling during the installation process prior to delivery to

the owner. If a component is cosmetically damaged to the extent that correction in the field is obvious against the factory finish, the component will be replaced with a new component finished from the factory. If a component is physically damaged due to mishandling or modification during the installation process, it shall not be used as part of the ladder rack system.

SECTION 27 15 00

COMMUNICATIONS HORIZONTAL CABLING

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Horizontal (distribution) communications wiring and connecting hardware from Telecommunications Room (TR) to Telecommunication Outlets (TO).

1.2 RELATED REQUIREMENTS

A. Section 27 05 26 – Grounding and Bonding for Communications Systems.

B. Section 27 05 28 – Pathways for Communications Systems.

C. Section 27 10 00 – Structured Cabling.

D. Section 27 11 00 – Communications Equipment Room Fittings.

E. Section 27 13 00 – Communications Backbone Cabling.

F. Section 27 16 00 – Communications Connecting Cords, Devices, and Adapters.

1.3 REFERENCE STANDARDS

A. ANSI TIA-492.CAAB – Detail Specification for Class Iva Dispersion-Unshifted Single-Mode Optical Fibers with Low Water Peak. Current Edition

B. ANSI/TIA 526 – OFSTP-19 Optical Signal-to-Noise Ratio Measurement Procedures for Dense Wavelength-Division Multiplexed Systems.

C. ANSI/TIA-568-C.0 – Generic Communications Cabling for Customer Premises..

D. ANSI/TIA-568-C.1 – Commercial Building Communications Cabling Standard Part 1: General Requirements.

E. ANSI/TIA 568-C.2 – Balanced Twisted-Pair Telecommunications Cabling and Components Standards

F. ANSI/TIA 568-C.3 – Optical Fiber Cabling Components Standard

G. ANSI/TIA-569-C – Commercial Building Standard for Telecommunications Pathways and Spaces.

H. ANSI/TIA-606-B – Administration Standard for the Commercial Telecommunications Infrastructure.

I. ANSI/JSTD-607-B – Commercial Building Bonding and Grounding (Earthing) Requirements for Telecommunications.

J. NFPA 70 – National Electrical Code (NEC).

K. BICSI – TDMM, Building Industries Consulting Services International, Telecommunications Distribution Methods Manual (TDMM)

1.4 PRE-INSTALLATION MEETINGS

A. Convene pre-installation meeting 2 weeks before start of installation of communications horizontal cabling.

B. Require attendance of parties directly affecting work of this section, including Contractor, Architect, installer, and manufacturer's representative.

C. Review materials, installation, field quality control, labeling, protection, and coordination with other work.

1.5 SUBMITTALS

A. Comply with Section 01 33 00 – Submittal Procedures.

B. Product Data: Submit manufacturer's product data sheets, including installation instructions verifying that materials comply with specified requirements and are suitable for intended application.

C. Installer's Project References: Submit installer's list of successfully completed communications horizontal cabling projects, including project name and location, name of architect, and type and quantity of communications horizontal cabling installed.

1.6 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Manufacturer regularly engaged, for past 5 years, in manufacture of communications horizontal cabling of similar type to that specified.

B. Installer's Qualifications:

1. Approved Leviton Optimized Installer or Berk-Tek Oasis Optimized Integrator Optimized before, during, and through completion of the system installation. Supporting documentation will be required as part of the submittal.

2. Responsible for workmanship and installation practices in accordance with Leviton Optimized Installer Program and Berk-Tek Oasis Program.

3. Communications Contractors shall have an office and maintain normal operations within 25 miles of downtown Tucson in order to reduce the carbon emission footprint.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Delivery and Acceptance Requirements: Deliver materials to site in manufacturer's original, unopened containers and packaging, with labels clearly identifying product name and manufacturer.

B. Storage and Handling Requirements:
   1. Store and handle materials in accordance with manufacturer's instructions.
   2. Keep materials in manufacturer's original, unopened containers and packaging until installation.
   3. Store materials in clean, dry area indoors.
   4. Protect materials during storage, handling, and installation to prevent damage.

1.8 WARRANTY

A. The horizontal communications cabling system installed shall be eligible for coverage by a Limited Lifetime Warranty to the end user.
   1. Horizontal channels shall be completed with Leviton Network Solutions factory-terminated copper and/or fiber optic patch cords in order to be eligible for the applicable Berk-Tek or Leviton Warranty with channel performance guarantees.
   2. Approved product shall be listed on the most recent version of the applicable Berk-Tek Leviton Technologies data sheets for each Berk-Tek Leviton Technologies solution.

B. Optimized Installer/Optimized Integrator shall provide labor, materials, and documentation in accordance with Berk-Tek and Leviton Network Solutions requirements necessary to ensure that the Owner will be furnished with a Limited Lifetime Warranty.

C. The installed structured cabling system shall provide a warranty guaranteeing installed channel performance above the ANSI/TIA 568-C requirements for Cat 6, and/or Cat 6A Atlas-X1 XTP cabling systems or ISO 11801 requirements for Cass D, Class E, and/or Class E_a.
   1. Standards-compliant channel or permanent link performance tests shall be performed in the field with a Berk-Tek Leviton Technologies approved certification tester in the appropriate channel or permanent link test configuration. See 1.8 A.1 above for channel requirements.

D. Necessary documentation for warranty registration shall be provided to the manufacturer by the installer (within 10 days) following 100 percent testing of cables.
   1. Submit test results to Leviton Network Solutions or to Berk-Tek, in the certification tester's original software files.

2. Installer shall ensure that the warranty registration is properly submitted, with all required documentation within 10 days of project completion.
3. Optimized Contractor/Optimized Integrator must adhere to the terms and conditions of the respective manufacturer's warranty programs.

E. Installer shall ensure that the Owner receives the manufacturer issued project warranty certificate within 60 calendar days of warranty registration.

F. Installer must recycle and use every measure to reduce waste on Pima County projects.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Leviton Network Solutions, 2222 222nd Street SE, Bothell, Washington 98021. Phone 425-486-2222. Fax 425-485-3373. Website www.leviton.com.

Berk-Tek, A Nexans Company, 132 White Oak Road, New Holland, PA 17557 Phone: 717-354-6200. Fax 717-354-7944. Website www.berktek.com.

2.2 SYSTEM DESCRIPTION

A. Horizontal Distribution Subsystem: Intra-building twisted-pair and fiber optic communications cabling connecting Telecommunication Rooms (TRs) to Telecommunication Outlets (TOs) located at individual work areas.

B. Horizontal Cabling: Combination of the following types of cables from TR to TO:
1. Category 6A Shielded Atlas-X1 CS6700 (100-Ohm, 4-pair, Foiled unshielded twisted pair) cables from TRs to TOs, all ports unless otherwise specified. – All new installations (Greenfield).

C. Communications Horizontal Cabling System: Includes cables, jacks, patch panels, connecting blocks, patch cords, fiber connectors, fiber adapter plates, fiber enclosures, jumpers, and necessary support systems, such as cable managers and faceplates.

D. Cables: Route through conduit, cable trays, spaces below raised floors, open ceiling areas, non-ventilated spaces above ceiling tile, and through plenum air-handling spaces above ceiling tile.

E. Furnish and install all materials necessary for a complete and working communications horizontal cabling system.

2.3 STATION CABLING

A. Category 6A Unshielded Twisted Pair with innovative crosstalk prevention (XTP) technology: **CX6850 Cat 6A Premium+ UTP System**. (Wireless Access Points and as Specified)

1. 100 ohm, Category 6A, 23 AWG, 4-pair unshielded twisted pair with innovative crosstalk prevention (XTP) technology. LANmark-XTP, CMP rated.

a. Color: Blue.
b. Part Number: 11082057.
c. Electrical Characteristics: Characterized to 750 MHz.
d. Cable: Third-party verified by ETL.
e. Maximum Cable Diameter: 0.275 inch.
f. Berk-Tek LANmark-XTP CMP
g. All category cabling manufacturers must be able to provide documentation from an independent third-party testing agency that verifies through random sampling that cable components perform at or above the levels contained on their product specifications, not simply at or above the standard.

2. 100 ohm, Category 6A, 23 AWG, 4-pair unshielded twisted pair with innovative crosstalk prevention (XTP) technology. LANmark-XTP, CMR rated.
   a. Color: Blue.
   b. Part Number: 11082062.
   c. Electrical Characteristics: Characterized to 750 MHz.
   d. Cable: Third-party verified by ETL.
   e. Maximum Cable Diameter: 0.275 inch.
   f. Berk-Tek LANmark-XTP CMR
   g. All category cabling manufacturers must be able to provide documentation from an independent third-party testing agency that verifies through random sampling that cable components perform at or above the levels contained on their product specifications, not simply at or above the standard.

3. Channel margin guarantees for a **CX6850 Cat 6A Premium+ UTP System** (margin vs. ANSI/TIA-568-C.2 and margin guarantees are for a 4-connector channel).

a.	Insertion Loss	3 %
b.	NEXT	5 dB
c.	PSNEXT	6 dB
d.	ACR-F (ELFEXT)	10 dB
e.	PSACR-F (PSELFEXT)	10 dB
f.	Return Loss	4 dB
g.	ACR-N	7 dB
h.	PSACR-N	7 dB
i.	PSANEXT	5 dB
j.	PSAACR-F	11 dB

B. Single-Mode Optical Fiber Cable. **OS2 Fiber Optic System**:
   1. Each Single-mode Fiber shall be:
      a) Dispersion - unshifted single mode optical fibers with Low Water Peak complying with ITU-T G.652.D and with improved bending loss complying with ITU-T G.657.A1.
      b) The zero dispersion wavelength shall be between 1300 nm and 1320 nm. The ANSI/EIA/TIA-455-168 maximum value of the dispersion slope shall be no greater than 0.090 ps/km-nm^2. Dispersion measurements shall be made in accordance with ANSI/EIA/TIA-455-169 or ANSI/EIA/TIA-455-175-B.
      c) The nominal mode field diameter shall be 9.2 μm with a tolerance of $\pm$ 0.4 μm at 1310 nm when measured in accordance with ANSI/EIA/TIA-455-191-B.
      d) Transmission Characteristics:
      e) Maximum cabled attenuation for loose tube fibers shall be 0.4/0.3 dB/km @ 1310/1550 nm.

f) Maximum cabled attenuation for tight buffer fibers shall be 0.7/0.7 dB/km @ 1310/1550 nm.
g) The cabled cutoff wavelength shall be ≤1260 nm when measured in accordance with ANSI/EIA/TIA-455-80-C.

2. Physical Characteristics:
   a) Shall be suitable for use in indoors or in indoor/outdoor applications.
   b) Appropriately flame rated optical cable shall be suitable for use in risers, plenums and horizontal applications.
   c) Plenum rated optical cables shall have and be marked with an UL-OFNP and OFN FT6 Flame Rating. Riser rated optical cables shall have and be marked with an UL-OFNR and OFN FT4 Flame Rating
   d) Shall comply with the requirements of ICEA S-83-596 (Premises), ICEA S-104-696 (I/O), or ANSI/ICEA S-87-640 (Outside Plant, OSP).
   e) Suitable for underground or aboveground conduits.
   f) Optical cables and fibers shall be color coded in accordance with EIA/TIA-598-C.
   g) Shall have a ripcord for overall jacket.

3. Design Make:

   a) **Berk-Tek Riser optical fiber cable with OS2 (Low Water Peak) Bend-insensitive Singlemode fiber**
      LTRxxxAB0403, (006 to 012 Bend-insensitive optical fibers, I/O Loose Tube)
      LTR12BxxxAB0403, (012 to 432 Bend-insensitive optical fibers, I/O Loose Tube)
      PDRxxxAB0707 (006 to 024 Bend-insensitive optical fibers, Indoor Tight Buffer)
      PDR12BxxxAB0707, (036 to 144 Bend-insensitive optical fibers, Indoor Tight Buffer)

2.4 MODULAR JACKS AND FIBER ADAPTERS FOR WORKSTATION OUTLETS

A. Category 6A Modular Jacks: **CX6850 Cat 6A Premium+ UTP System.**
1. 8-position modular jack, Category 6A, IDC terminals, T568A/B wiring scheme.
2. The modular connector shall exceed all component performance requirements in the ANSI/TIA-568-C.2 standard for Augmented Category 6 from 1 MHz to 500 MHz to support the IEEE 802.3an standard for 10GBASE-T network performance
3. The Modular Connector shall be terminated without the need for any punch down tool or other specialized or proprietary termination tool.
4. The Connector Module shall feature a termination wire manager that holds individual conductors in place during termination.
5. The Category 6A Modular Connector termination method shall be consistent with the termination method available for Category 5e and Category 6 UTP modules from the same manufacturer. The same termination method shall also be consistent with Category 5e, 6 and 6A shielded modules from the same manufacturer.
6. The Modular Connector shall be reusable and support multiple termination and re-termination cycles and be facilitated by simple termination release levers.
7. The modular connector shall be independently tested and verified by Intertek (ETL) to exceed Category 6A component performance.
8. The eight-position connector module shall utilize a method of tine tensioning that prevents six-position modular plug insertion from damaging either the cord or the module.
9. The connector body shall be made of die-cast zinc and all plastic components shall be made of high-impact, fire-retardant plastic rated UL 94V-0.

10. The connector shall also be in compliance will all National Electrical Codes; compliant with ANSI/TIA-1096-A (formerly FCC Part 68); cULus Listed; and independently tested for component compliance.
11. In addition to Category 6A component compliance, the connector shall have the ability to support high megabit and shared sheath applications.
12. Connector wiring shall be universal and will accommodate both T568A and T568B pair/pin assignments.
13. The connector shall incorporate a triple-stage compensation design with integrated flexible circuit design that enhances link and channel performance.
14. The modular connector shall fit a range of telecommunications faceplates, outlets, and field-configurable patch panels.
15. The modular connector shall be available in 13 TIA 606-A compatible colors.
16. Connector Module shall be supplied with interchangeable icons (voice, data, A/V, and blank, color coded to match the connector face) for easy identification and tracking of data, voice, or other functions.
17. Additional bulk Icons for the connector shall be available in 13 colors to facilitate a broad range of connector marking/identification options.
18. Connector Modules shall be available with an internal shutter to protect against dust and debris
19. Connector Module shall have a maximum depth of 1.31”
20. Each connector shall be identified on its face as CAT 6A.
21. Basis for design: Leviton Atlas-X1 UTP Cat 6A Connector. Plenum Rated (UL Standard 2043).
22. Color: white (13 colors available).
23. Part Numbers: Standard version: 6AUJK-RWY (Yellow). (As specified by Owner)
    Shutter version: 6AUJK-SY6 (Yellow).
    Additional Icons: ICONS-IC* (72 two-sided Icons)
    * = color option

B. Single Mode Fiber Modular Adapters for workstation outlets: Use for **OS2 Fiber Optic System**.

1. QuickPort Duplex LC Adapter, blue adapter for OS1/OS2 Single Mode fiber, zirconia ceramic sleeve.
   a. Color of plastic housing: ivory
   b. Part Number: Leviton 41085-SLI (ivory).
2. QuickPort Simplex SC Adapter, for OS1/OS2 Single Mode fiber, zirconia ceramic sleeve.
   a. Color of plastic housing: ivory
   b. Part Number: Leviton 41085-SIC (ivory).

2.5 WORK AREA OUTLETS

A. Flush-Mounted Plastic Faceplates:
1. 1-port single-gang plastic wallplate with ID windows.
   a. Colors: ivory
   b. Part Number: Leviton 42080-1IS (ivory).
2. 2-port single-gang plastic wallplate with ID windows.
   a. Colors: ivory
   b. Part Number: Leviton 42080-2IS (ivory).
3. 3-port single-gang plastic wallplate with ID windows.
   a. Colors: ivory
   b. Part Number: Leviton 42080-3IS (ivory).

4. 4-port single-gang plastic wallplate with ID windows.
   a. Colors: ivory
   b. Part Number: Leviton 42080-4IS (ivory).
5. 6-port single-gang plastic wallplate with ID windows.
   a. Colors: ivory
   b. Part Number: Leviton 42080-6IS (ivory).

6. 4-port dual-gang plastic wallplate with ID windows.
   a. Colors: ivory
   b. Part Number: Leviton 42080-4IP (ivory).
7. 6-port dual-gang plastic wallplate with ID windows.
   a. Colors: ivory
   b. Part Number: Leviton 42080-6IP (ivory).
8. 8-port dual-gang plastic wallplate with ID windows.
   a. Colors: ivory
   b. Part Number: Leviton 42080-8IP (ivory).
9. 12-port dual-gang plastic wallplate with ID windows.
   a. Colors: ivory
   b. Part Number: Leviton 42080-12I (ivory).
10. Faceplate Colors: Coordinate with Architect to match finish. Part numbers shown are for standard color of white. Also available in Light Almond, Ivory, Grey, and Black.

B. Flush-Mounted Stainless Steel Faceplates:
1. 1-port QuickPort faceplate with mounting lugs for wall phone, stainless steel, mounts onto single-gang wall box.
   a. Part Number: Leviton 4108W-0SP (flush plate) or 4108W-1SP (jack area recessed).
2. 1-port QuickPort single-gang stainless steel wallplate, with ID windows
   a. Part Number: Leviton 43080-1L1.
3. 2-port QuickPort single-gang stainless steel wallplate, with ID windows
   a. Part Number: Leviton 43080-1L2.
4. 3-port QuickPort single-gang stainless steel wallplate, with ID windows
   a. Part Number: Leviton 43080-1L3.
5. 4-port QuickPort single-gang stainless steel wallplate, with ID windows
   a. Part Number: Leviton 43080-1L4.
6. 6-port QuickPort single-gang stainless steel wallplate, with ID windows
   a. Part Number: Leviton 43080-1L6.
7. 2-port QuickPort dual-gang stainless steel wallplate, with ID windows
   a. Part Number: Leviton 43080-2L2.
8. 6-port QuickPort dual-gang stainless steel wallplate, with ID windows
   a. Part Number: Leviton 43080-2L6.
9. 8-port QuickPort dual-gang stainless steel wallplate, with ID windows
   a. Part Number: Leviton 43080-2L8.

C. Surface-Mounted Outlet Boxes (Plenum Rated) for WAP Installations:
1. 1-port QuickPort surface-mount box, plastic, with ID window.
   a. Color: ivory
   b. Part Number: Leviton 41089-1IP (ivory).
2. 2-port QuickPort surface-mount box, plastic, with ID window.
   a. Color: ivory
   b. Part Number: Leviton 41089-2IP (ivory).

3. 2-port QuickPort surface-mount box, plastic, with ID window, extra-deep for shielded connectors, Cat 6A, other larger bend-radius cable applications.
    a. Color: ivory
    b. Part Number: Leviton 4S089-2IP (ivory)

D. Surface-Mounted Outlet Boxes (Plenum Rated):
1. 1-port QuickPort surface-mount box, plastic, with ID window.
    a. Color: white
    b. Part Number: Leviton 41089-1WP (white).
2. 2-port QuickPort surface-mount box, plastic, with ID window.
    a. Color: white
    b. Part Number: Leviton 41089-2WP (white).
3. 4-port QuickPort surface-mount box, plastic, with ID window.
    a. Color: white
    b. Part Number: Leviton 41089-4WP (white).
4. 6-port QuickPort surface-mount box, plastic, with ID window.
    a. Color: white
    b. Part Number: Leviton 41089-6WP (white).
5. 12-port QuickPort surface-mount box, plastic, with ID window.
    a. Color: white
    b. Part Number: Leviton 41089-12W (white)
6. 2-port QuickPort surface-mount box, plastic, with ID window, extra-deep for shielded connectors, Cat 6A, other larger bend-radius cable applications.
    a. Color: white
    b. Part Number: Leviton 4S089-2WP (white)
7. 4-port QuickPort surface-mount box, plastic, with ID window, extra-deep for shielded connectors, Cat 6A, other larger bend-radius cable applications.
    a. Color: white
    b. Part Number: Leviton 4S089-4WP (white)
8. Surface Box Colors: part numbers shown are for white. Also available: Ivory, Grey, and Black.
    a. Coordinate with Architect to match finish.
    b. (Compliant with NEC 300-22 (b)

E. Modular Furniture Faceplates:
1. 2-port furniture wallplate fits 1.38-inch by 2.63-inch furniture knockout, with ID window.
    a. Colors: ivory
    b. Part Number: Leviton 49910-SI2 (ivory).
2. 4-port furniture wallplate fits 1.38-inch by 2.63-inch furniture knockout, with ID window.
    a. Colors: ivory
    b. Part Number: Leviton 49910-SI4 (ivory).
3. 4-port furniture wallplate fits 1.38-inch by 2.63-inch furniture knockout, with ID window. Extra-deep version with additional room for cable bend radius.
    a. Colors: ivory
    b. Part Number: Leviton 49910-EI4 (ivory).
4. 2-port furniture wallplate fits 1.88-inch by 2.98-inch Hermann-Miller furniture knockout, with ID window.
    a. Colors: ivory
    b. Part Number: Leviton 49910-HI2 (ivory).
5. 4-port furniture wallplate fits 1.88-inch by 2.98-inch Hermann-Miller furniture knockout, with ID window.

a. Colors: ivory
b. Part Number: Leviton 49910-HI4 (ivory).

6. Furniture Faceplate Colors: Part numbers shown are for white. Also available: Ivory, grey, and black. Coordinate with Architect to match finish.

F. Mounting Frames for QuickPort Jacks and Connectors
1. 1-port QuickPort Decora-style frame. Fits in Decora-style wallplate
a. Colors: white
b. Part Number: Leviton 41641-00I (ivory).
2. 2-port QuickPort Decora-style frame. Fits in Decora-style wallplate
a. Colors: white
b. Part Number: Leviton 41642-00I (ivory).
3. 3-port QuickPort Decora-style frame. Fits in Decora-style wallplate
a. Colors: white
b. Part Number: Leviton 41643-00I (ivory).
4. 4-port QuickPort Decora-style frame. Fits in Decora-style wallplate
a. Colors: white
b. Part Number: Leviton 41644-00I (ivory).
5. 6-port QuickPort Decora-style frame. Fits in Decora-style wallplate
a. Colors: white
b. Part Number: Leviton 41646-00I (ivory)
6. 2-port QuickPort Duplex 106-style frame. Fits in Duplex electrical-style wallplate
a. Colors: white
b. Part Number: Leviton 41087-2IP (ivory).
7. Decora-style wallplates for above mounting frames
a. Single-gang, nylon: Leviton part number 80401-0NI (ivory)
b. Dual-gang, nylon: Leviton part number 80409-0NI (ivory)
8. 4-port QuickPort Duplex 106-style frame. Fits in Duplex electrical-style wallplate
a. Colors: ivory
b. Part Number: Leviton 41087-QIP (ivory).
9. Duplex electrical-style wallplates for above mounting frames
a. Single-gang, nylon: Leviton part number 80703-00I (ivory)
b. Dual-gang, nylon: Leviton part number 80716-00I (ivory)

G. Mounting Frame colors: Part numbers shown are for white. Also available: Light almond, ivory, grey, black (and brown for the Decora-style frames). Coordinate with Architect to match finish.

H. In-Ceiling Brackets - Mounting QuickPort Jacks, Connectors, 1 & 2 Port Surface Mounted Box, Slack Loops.
1. QuickPort In-Ceiling 2 Port Bracket, includes clip for drop wire/rod
a. Colors: Metal
b. Part Number: Leviton 49223-CBC.
2. QuickPort In-Ceiling 2 Port Bracket, no clip .
a. Colors: Metal
b. Part Number: Leviton 49923-CB0.

I. Multimedia Outlet System (MOS):
1. Single-gang Multimedia Outlet System wallplate, plastic, with ID windows. Holds a wide variety of copper, fiber, and/or audio-video inserts.
a. Color: ivory
b. Part Number: Leviton 41290-SMI (ivory).

2. Dual-gang Multimedia Outlet System wallplate, plastic, with ID windows. Holds a wide variety of copper, fiber, and/or audio-video inserts.
   a. Color: ivory
   b. Part Number: Leviton 41290-DMI (ivory).
3. Multimedia Outlet System wallplates, Stainless Steel, with ID windows. Holds a wide variety of copper, fiber, and/or audio-video inserts.
   a. Color: Stainless Steel
   b. Part Numbers: Single-gang Leviton 41290-SMS (Stainless).
      Dual-gang Leviton 41290-DMS (Stainless).
      Three-gang Leviton 41290-TMS (Stainless).
4. Fiber storage/spacer ring, plastic. Fits Dual-gang Multimedia Outlet System wallplate.
   a. Color: ivory
   b. Part Number: Leviton 41290-DRI (ivory).
5. 6-port Multimedia Outlet System surface-mount box, plastic, with ID window. Holds a wide variety of copper, fiber, and/or audio-video inserts.
   a. Color: white
   b. Part Number: Leviton 41290-SMI (ivory).
6. Multimedia Outlet System (MOS) colors: Part numbers shown are for ivory. Coordinate with Architect to match finish.
7. Multimedia Outlet System (MOS) Inserts: For a complete list of MOS Inserts available please visit www.leviton.com/mos

2.6 PATCH PANELS

A. QuickPort-Style Patch Panels: **CX6850 Cat 6A Premium+ UTP System.** (As specified)
   1. 24-port, 1RU, QuickPort, flat metal, patch panel, empty.
      a. Part Number: Leviton 49255-H24.
   2. 48-port, 1RU, QuickPort, flat metal, patch panel, empty.
      a. Part Number: Leviton 49255-H48.
   3. 24-port, 1RU, QuickPort, angled metal, patch panel, empty.
      a. Part Number: Leviton 49256-H24.
   4. 48-port, 2RU, QuickPort, angled metal, patch panel, empty.
      a. Part Number: Leviton 49256-H48.
   5. 48-port, 1RU high-density, QuickPort, flat metal, patch panel, empty.
      a. Part Number: Leviton 49255-Q48.
   6. 48-port, 1RU high-density, QuickPort, angled metal, patch panel, empty.
      a. Part Number: Leviton 49256-D48.

2.7 FIBER OPTIC TERMINATION ENCLOSURES and SPLICE TRAYS. Use for **OS2 Fiber Optic Systems**

A. Opt-X 1000i Fiber Optic Enclosures: High-end features, all metal enclosure, rack mountable, holds various fiber adapter plates, splice trays, or MTP modules, based on connector choice and density requirements.
   1. 1RU Opt-X 1000i rack-mount Fiber Optic Enclosure, empty, with sliding tray.
      a. Capacity: 72 fiber strands (LC), 3 fiber adapter plates and 3 splice trays, or 3 MTP modules
      b. Part Number: Leviton 5R1UM-S03.
   2. 2RU Opt-X 1000i rack-mount Fiber Optic Enclosure, empty, with sliding tray.

a. Capacity: 144 fiber strands (LC), 6 fiber adapter plates and 6 splice trays, or 6 MTP modules
b. Part Number: Leviton 5R2UM-S06.

3. 3RU Opt-X 1000i rack-mount Fiber Optic Enclosure, empty.
   a. Capacity: 216 fiber strands (LC), 9 fiber adapter plates and 9 splice trays, or 9 MTP modules
   b. Part Number: Leviton 5R3UM-F09.
4. 4RU Opt-X 1000i rack-mount Fiber Optic Enclosure, empty.
   a. Capacity: 288 fiber strands (LC),12 fiber adapter plates and 12 splice trays, or 12 MTP modules
   b. Part Number: Leviton 5R4UM-F12.

B. Opt-X Ultra HD Fiber Optic Enclosures
1. 1RU Opt-X Ultra HD rack-mount Fiber Optic Enclosure, empty, with sliding tray.
   a. Capacity: 96 fiber strands (LC), 4 Opt-X HD fiber adapter plates or 4 Opt-X HD MTP cassette modules
   b. Part Number: Leviton 5R1UH-S08
2. 2RU Opt-X Ultra HD rack-mount Fiber Optic Enclosure, empty, with sliding tray.
   a. Capacity: 192 fiber strands (LC), 8 Opt-X HD fiber adapter plates or 8 Opt-X HD MTP cassette modules
   b. Part Number: Leviton 5R1UH-S16

C. Opt-X Ultra Fiber Optic Enclosures: High-end appearance, metal and composite, rack mountable, holds various fiber adapter plates, splice trays, or MTP modules, based on connector choice and density requirements.
1. 1RU Opt-X Ultra rack-mount Fiber Optic Enclosure, empty, with sliding tray.
   a. Capacity: 72 fiber strands (LC), 3 fiber adapter plates and 3 splice trays, or 3 MTP modules
   b. Part Number: Leviton 5R1UH-S03.
2. 2RU Opt-X Ultra rack-mount Fiber Optic Enclosure, empty, with sliding tray.
   a. Capacity: 144 fiber strands (LC), 6 fiber adapter plates and 6 splice trays, or 6 MTP modules
   b. Part Number: Leviton 5R2UH-S06.
3. 4RU Opt-X Ultra rack-mount Fiber Optic Enclosure, empty, with sliding tray.
   a. Capacity: 288 fiber strands (LC),12 fiber adapter plates and 12 splice trays, or 12 MTP modules
   b. Part Number: Leviton 5R4UH-S12.

D. Splice Trays
1. 12-fiber Mini Splice Tray, 3.74” x 5.59”
   a. Part Number: Leviton T5PLS-12F
2. 24-fiber High-density Splice Tray, 4.5” x 7.63”
   a. Part Number: Leviton T5PLS-24F

E. Splice Cassettes
1. Use for **OS2 Fiber Optic System**
   a. Opt-X 12-Fiber LC OS2 Splice Module
      1) Part Number: Leviton SPLCS-12L
   b. Opt-X 12-Fiber LC/APC OS2 Splice Module
      1) Part Number: Leviton SPLCS-12V
   c. Opt-X 12-Fiber SC OS2 Splice Module

1) Part Number: Leviton SPSCS-12L
d. Opt-X 12-Fiber SC/APC OS2 Splice Module
1) Part Number: Leviton SPSCS-12V
e. Opt-X 24-Fiber LC OS2 Splice Module
1) Part Number: Leviton SPLCS-24L
f. Opt-X 24-Fiber LC/APC OS2 Splice Module
1) Part Number: Leviton SPLCS-24V

2.8 FIBER OPTIC ADAPTER PLATES

A. Single Mode Adapter Plates, for **OS2 Fiber Optic System**.
1. 6-LC duplex (12-fiber) singlemode OS1/OS2, blue adapter plate, zirconia-ceramic sleeves.
a. Part Number: Leviton 5F100-2LL.
2. 6-LC quad (24-fiber) singlemode OS1/OS2, blue adapter plate, zirconia-ceramic sleeves.
a. Part Number: Leviton 5F100-4LL.
3. 6-SC duplex (12-fiber) singlemode OS1/OS2, blue adapter plate, zirconia-ceramic sleeves.
a. Part Number: Leviton 5F100-2LC.

B. Opt-X HD Fiber Adapter Plates (for Opt-X 1000i HD Fiber Enclosures) Use for **OS2 Fiber Optic Systems**, as specified.
1. OS2, Quad LC (Blue), 12 fibers, Zirconia Ceramic Sleeve
a. Part Number: Leviton 5FUHD-6LL
2. OS2, Duplex SC (Blue), 6 fibers, Zirconia Ceramic Sleeve
a. Part Number: Leviton 5FUHD-6LC
3. Opt-X HD Blank Adapter Plate (Black)
a. Part Number: Leviton 5FUHD-BLK

2.9 MTP FIBER OPTIC CASSETTE MODULES (Data Center)

A. Opt-X Unity 40/100 MTP Cassette Modules for 50µm LOMM fiber, OM3 and OM4. Use for **OM3 Fiber Optic System.**
1. Use configurator for optioning Opt-X Unity 40/100 MTP Cassettes
a. www.leviton.com/configurator

B. www.leviton.com/configuratorOpt-X HD MTP Cassettes for Opt-X Ultra HD and Opt-X 1000i HD Fiber Enclosures
1. Use configurator for optioning Opt-X HD MTP Cassettes
a. www.leviton.com/configurator (verify all configurations with Technical Support Team)

2.10 FIBER OPTIC CONNECTORS

A. OS2 Single Mode Fiber Optic Connectors (blue): Use for **OS2 Fiber Optic System**
1. FastCam LC Connector
a. Part Number: Leviton 49991-SLC
2. FastCam SC Connector
a. Part Number: Leviton 49991-SSC

2.11 PATCH CORDS/JUMPERS

A. Atlas-X1 Category 6 Modular Patch Cords: **CX6300 Cat 6 Premium+ UTP System.**
   1. Slim-Line style, Category 6 UTP patch cord, 4-pair, stranded wire construction.
      b. Color: 9 colors available.
      c. Part Numbers:
         1) Leviton 6AS10-03L (3 feet, Blue).
         2) Leviton 6AS1-03O (3 feet, Orange).
         3) Leviton 6AS10-05L (5 feet, Blue).
         4) Leviton 6AS10-05O (5 feet, Orange).
         5) Leviton 6AS10-07L (7 feet, Blue).
         6) Leviton 6AS10-07O (7 feet, Orange).
         7) Leviton 6AS10-10L (10 feet, Blue).
         8) Leviton 6AS10-10O (10 feet, Orange).
         9) Leviton 6AS10-15L (15 feet, Blue).
         10) Leviton 6AS10-15O (15 feet, Orange).
         11) Leviton 6AS10-20L (20 feet, Blue).
         12) Leviton 6AS10-20O (20 feet, Orange).

B. Single Mode Fiber Optic Jumpers:

   1. OS2, yellow. Factory-terminated, double-ended, 2-strand singlemode cordage, UPC polish. Use for **OS2 Fiber Optic System**
      a. Duplex LC-Duplex LC:
         1) Leviton UPDLC-S01 (1 meter)
         2) Leviton UPDLC-S02 (2 meter)
         3) Leviton UPDLC-S03 (3 meter)
         4) Leviton UPDLC-S05 (5 meter)
         5) Leviton UPDLC-S10 (10 meter)

      b. Duplex SC-Duplex SC:
         1) Leviton UPDSC-S01 (1 meter)
         2) Leviton UPDSC-S02 (2 meter)
         3) Leviton UPDSC-S03 (3 meter)
         4) Leviton UPDSC-S05 (5 meter)
         5) Leviton UPDSC-S10 (10 meter)

      c. Duplex SC-Duplex LC:
         1) Leviton UPDCL-S01 (1 meter)
         2) Leviton UPDCL-S02 (2 meter)
         3) Leviton UPDCL-S03 (3 meter)
         4) Leviton UPDCL-S05 (5 meter)
         5) Leviton UPDCL-S10 (10 meter)

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine areas to receive communications horizontal cabling.

B. Notify Architect of conditions that would adversely affect installation or subsequent use.

C. Do not begin installation until unacceptable conditions are corrected.

3.2 INSTALLATION – GENERAL

A. Install communications horizontal cabling in accordance with manufacturer's instructions, ANSI/TIA-568-C.0, ANSI/TIA-568-C.1, ANSI/TIA-569-C, BICSI TDMM, and NFPA 70.

B. Field Terminated Copper and Fiber Optic Patch Cords and Jumpers: Not allowed.

C. Copper Patch Cords and Fiber Jumpers: Manufactured by Leviton Network Solutions.

D. Install cables after building interior has been physically protected from weather and mechanical work likely to damage cabling has been completed.

E. Ensure cable pathways are completely and thoroughly cleaned before installing cabling.

F. Inspect installed conduit, wireway, cable trays, and innerduct.

G. Clean additional enclosed raceway and innerduct systems furnished.

H. Provide protection for exposed cables where subject to damage.

I. Abrasion Protection:
   1. Provide abrasion protection for cable or wire bundles which pass through holes or across edges of sheet metal.
   2. Use protective bushings to protect cables.

J. Cable Ties and Other Cable Management Clamps:
   1. No more than hand tightened.
   2. Fit snugly, but not compress, crimp, or otherwise change physical characteristics of cable jacket or distort placement of twisted-pair components.
   3. Replace cables exhibiting stresses due to over tightening of cable management devices.
   4. Use plenum-rated cable ties in plenum spaces.
   5. Velcro wraps are preferred over cable ties for all cable bundles. Plenum-rated Velcro wraps are available from Leviton.

K. Where possible, route cables in overhead cable trays and inside wire management systems attached to equipment cabinets and racks.
   1. Use Velcro, plastic ties or ducts to restrain cabling installed outside of wire management systems on racks or in cabinets.
   2. Cable Trays: Do not exceed 50 percent fill.

L. Pull Cord:
   1. Nylon, 1/8-inch minimum.
   2. Co-install with cables installed in conduit.

M. Cable Raceways: Do not fill greater than ANSI/TIA-569-B maximum fill for particular raceway type.

N. Support horizontal cables at a maximum of 48-inch (1.2 to 1.5-m) irregular intervals, if J-hook or trapeze system is used to support cable bundles.

O. Do not allow cables to rest on acoustic ceiling grids, plumbing pipes, or electrical conduits.

P. Bundle horizontal distribution cables in groups of no more than amount of cables designed for by cable support manufacturer, based on cable OD and weight.

Q. Fire-Sprinkler System:
   1. Install cables above fire-sprinkler system.
   2. Do not attach cables to fire-sprinkler system or ancillary equipment or hardware.
   3. Install cable system and support hardware so that it does not obscure valves, fire alarm conduit, boxes, or other control devices.

R. Do not attach cables to ceiling grid or lighting fixture wires.

S. Install appropriate carriers to support cabling, where support for horizontal cables are required.

T. Replace before final acceptance, cables damaged or exceeding recommended installation parameters during installation.

3.3 INSTALLATION – FOILDED UNSHIELDED TWISTED-PAIR CABLES

A. Install unshielded twisted-pair cables in accordance with manufacturer's instructions.

B. Install cables in continuous lengths from origin to destination, without splices, except for transition points or consolidation points.

C. Where transition points or consolidation points are allowed, they shall be located in accessible locations and housed in enclosure intended and suitable for the purpose.

D. Cable Minimum Bend Radius and Maximum Pulling Tension:
   1. Do not exceed bend radius for UTP = 4 X Cable OD, FTP = 4 X Cable OD.
   2. Install unshielded twisted-pair cables so that there are no bends smaller than 4 times cable outside diameter at any point in the run and at the termination field.
   3. Pulling Tension on 4-Pair UTP Cables: Do not exceed 25 ft.lb. for 4-pair UTP cable.

E. Separation from Power Lines: Provide following minimum separation distances between pathways for copper communications cables and power wiring of 480 volts or less:
   1. Open or Nonmetal Communications Pathways:
      a. Electric motors, fluorescent light fixtures, and unshielded power lines carrying up to 3 kVA: 12 inches.
      b. Electrical equipment and unshielded power lines carrying more than 5 kVA: 36 inches.

c. Large electrical motors or transformers: 48 inches.

2. Grounded Metal Conduit Communications Pathways:
   a. Electrical equipment and unshielded power lines carrying up to 2 kVA: 2-1/2 inches.
   b. Electrical equipment and unshielded power lines carrying from 2 kVA to 5 kVA: 6 inches.
   c. Electrical equipment and unshielded power lines carrying more than 5 kVA: 12 inches.
   d. Power lines enclosed in grounded metal conduit (or equivalent shielding) carrying from 2 kVA to 5 kVA: 3 inches.
   e. Power lines enclosed in grounded metal conduit (or equivalent shielding) carrying more than 5 kVA: 6 inches.

3.4 INSTALLATION – UNSHIELDED TWISTED-PAIR TERMINATION

A. Coil cables to house cable coil without exceeding manufacturer's bend radius.
   1. In hollow wall installations where box eliminators are used, store excess wire in wall.
   2. Store no more than 12 inches of FTP and 36 inches of fiber slack.
   3. Loosely coil excess slack and store in ceiling above each drop location, when there is not enough space present in outlet box to store slack cables.

B. Dress and terminate cables in accordance with ANSI/TIA-568-C.0, ANSI/TIA- C.1, BICSI TDMM, and manufacturer's instructions.

C. Terminate 4-pair cables on jack and patch panels using T568-B or T568-A wiring scheme.

D. Pair Untwist at Termination: Do not exceed 12 mm (1/2 inch).

E. Bend Radius of Horizontal Cables:
   1. Not less than 4 times OD of FTP cables.

F. Maintain cable jacket to within 25 mm (1 inch) of termination point.

G. Neatly bundle cables and dress to their respective panels or blocks.
   1. Feed each panel or block by individual bundle separated and dressed back to point of cable entrance into rack or frame.

3.5 INSTALLATION – OPTICAL FIBER CABLES

A. Place fiber optic cables to maintain minimum cable bend radius limits specified by manufacturer or 15 times cable diameter, whichever is larger.

B. Use care when handling fiber optic cables.
   1. Carefully monitor pulling tension so as not to exceed limits specified by manufacturer.

C. Do not splice horizontal fiber optic cables.

3.6 FIELD QUALITY CONTROL

A. Cables and Termination Hardware: Test 100 percent for defects in installation and verify cabling system performance under installed conditions in accordance with ANSI/TIA-568-C.0.

1. Verify all pairs of each installed cable before system acceptance.
2. Defects in cabling system installation, including but not limited to cables, connectors, patch panels, and connector blocks shall be repaired or replaced to ensure 100 percent useable conductors in all cables installed.

B. Test all cables in accordance with this specification section, ANSI/TIA-568-C.2, and ANSI/TIA-568-C.3 standards, and Berk-Tek and Leviton Network Solutions instructions
   1. If any of these are in conflict, bring discrepancies to the attention of the Architect for clarification and resolution.

C. Cables, Jacks, Connecting Blocks, and Patch Panels:
   1. Verify all pairs of each installed cable before system acceptance.
   2. Defects in cabling system installation, including but not limited to cables, connectors, patch panels, and connector blocks shall be repaired or replaced to ensure 100 percent useable conductors in all cables installed.

D. Testing Unshielded Twisted-Pair Cables: (**NOTE: Permanent Link Test results are recommended, and are the expected norm** – unless patch cords that will remain installed at the work area and cross-connect are also being tested, in which case Channel Test results would be expected and accepted).
   1. Test twisted-pair copper cable links for continuity, pair reversals, shorts, opens, and performance as specified.
      a. Additional testing is required to verify Category performance.
      b. Test horizontal cabling using approved certification tester for Category 6A performance compliance in accordance with ANSI/TIA-568-C.2. (NOTE: Appropriate Fluke certification testers shall be used).
      c. Category 6A shall conform to ANSI/TIA-568-C.2 for augmented Category 6 to 500 MHz.
   2. Follow ANSI/TIA-568-C.2.
   3. Basic Tests Required:
      a. Wire map.
      b. Length (feet).
      c. Insertion loss (dB), formerly attenuation.
      d. NEXT (Near end crosstalk) (dB).
      e. Return loss (dB).
      f. ELFEXT (dB).
      g. Propagation delay (ns).
      h. Delay skew (ns).
      i. PSNEXT (Power sum near-end crosstalk loss) (dB).
      j. PSELFEXT (Power sum equal level far-end crosstalk loss) (dB).
   4. Test Category 6A by auto test to 500 MHz.
      a. Alien Crosstalk (AXT) testing and AXT test results are NOT required by Leviton or Berk-Tek for warranty of a Category 6A system. (**Note**: AXT testing may be required by the customer, in which case these tests WOULD have to be performed).
   5. Provide test results in approved certification testers original software format on CD, with the following minimum information per cable:
      a. Circuit ID.
      b. Information from specified basic tests required.
      c. Test Result: “Pass” or “Fail”.
      d. Date and time of test.
      e. Project name.

f. NVP.
g. Software version.

6. An occasional asterisk-Pass (*Pass) will be accepted by Leviton or Berk-Tek at the manufacturer's discretion, but rework of these links should be done in an attempt to achieve clean "Pass" results prior to submission of test results.
7. To receive Manufacturer's Warranty for the project, submit software copy of test results, in original tester software format, to the Owner and to the Manufacturer (either Berk-Tek or Leviton).
8. Submit fully functional version of tester software for use by the Owner in reviewing test results.
9. Report in writing to the Owner immediately, along with copy of test results, failed test results that cannot be remedied through re-termination (as in the case of reversed or split pairs).

E. Optical Fiber:
1. Testing procedures shall be in accordance with the following:
a. ANSI/TIA-568-C.3.
b. ANSI/TIA-526-7, Method B.
c. Proposed TSB-140 Tier One Fiber Certification, C.
d. Encircled Flux testing per the TSB-4979 and TIA-526-14-B standard.
2. Test Equipment: Certification tester (Note: Fluke testers shall be used).
3. Testing:
a. Test optical fibers at both 1310 nm and 1550 nm wavelengths for singlemode, end-to-end insertion loss, Telecommunications Room (TR) to Telecommunications Outlet (TO), Telecommunications Outlet (TO) to Telecommunications Room (TR).
b. Maximum insertion loss for horizontal fiber optic cables without consolidation point: 2.0 dB.
c. Test horizontal fiber runs TR to TO, TO to TR, at wavelength of operation to desktop applications.
4. Submit software copy of test results, in original tester software format, to the Owner and to the Manufacturer (either Berk-Tek or Leviton).

3.7 LABELING

A. All labeling is to be in accordance with ANSI/TIA-606-B and manufacturer's instructions.

B. Label horizontal cables using machine-printed label at each end of cable at approximately 12 inches from termination point and again at approximately 48 inches from termination point.
1. Handwritten Labels: Not acceptable.

C. Label patch panel ports and TO ports with cable identifier.

D. Labels: Denote TO ID and unique cable number for that TO, i.e. A-001-A for cable number 1, A-001-B for cable number 2, and so forth.
1. Owner may provide specific labeling requirements. Coordinate with the Owner.

E. Note labeling information on as-built drawings.

3.8 PROTECTION

A. Protect installed communications horizontal cabling from damage during construction.

SECTION 27xxx

NON-CONTINUOUS CABLE SUPPORTS FOR HIGH-SPEED TRANSMISSION CABLES (CATEGORY 5e AND HIGHER, AND OPTICAL FIBER CABLES) – HIGH PERFORMANCE J-HOOKS

PART 1 – HIGH PERFORMANCE NON-CONTINUOUS CABLE SUPPORT (HPNCCS) SYSTEMS

1.1 HPNCCS

1. HPNCCS shall be available in diameter sizes of 25 mm (1 in), 33 mm (1 5/16”), 50 mm (2 in), 75 mm (3 in) and 100 mm (4 in)
2. HPNCCS shall provide a bearing surface of sufficient width to comply with required bend radii of high-performance cables; cULus Listed.
3. HPNCCS shall have flared edges to prevent damage while installing cables.
4. HPNCSS shall meet the bend radius support requirements of supporting 4 times outer diameter (O.D.) per TIA-C.5.3.2.1; all edges shall support a bend radius of 1 ½” or more.
5. HPNCCS shall support bend radius requirements on the “neck” to allow for pathways around corners
6. HPNCCS shall have a cable retainer wire form to provide containment of cables within the hanger. The cable retainer shall be removable and reusable.
7. HPNCCS shall have an electro-galvanized, G60, or powder coated finish and shall be rated for indoor use in non-corrosive environments.
8. Acceptable ERICO products: CADDY® CAT16HP, CADDY CAT21HP, CADDY CAT32HP, CADDY CAT48HP, CADDY CAT64HP. Colored HPNCCS have the two-letter color code added to the product number (e.g., CADDY CAT32HPRD). The color code is: RD (red), BU (blue), BA (black), WH (white), YL (yellow), GR (green) and OR (orange).

cULus is a registered trademark of Underwriters Laboratories, Inc.
TIA is a registered service mark of the Telecommunications Industry Association.

END OF SECTION

Graphic Diagrams:

The following section will show examples to follow for existing installations. All new work shall be a Berk-Tek Leviton Technologies product solution and be backed by a Lifetime Warranty. A preconstruction meeting with Chris Garcia will be required prior to start of construction to cover any installation best practices and/or changes. Please see figures 1-9 below. For TI and Legacy installs, match existing. For all new builds please reach out to Pima County ITD “TeleCable” Project Managers

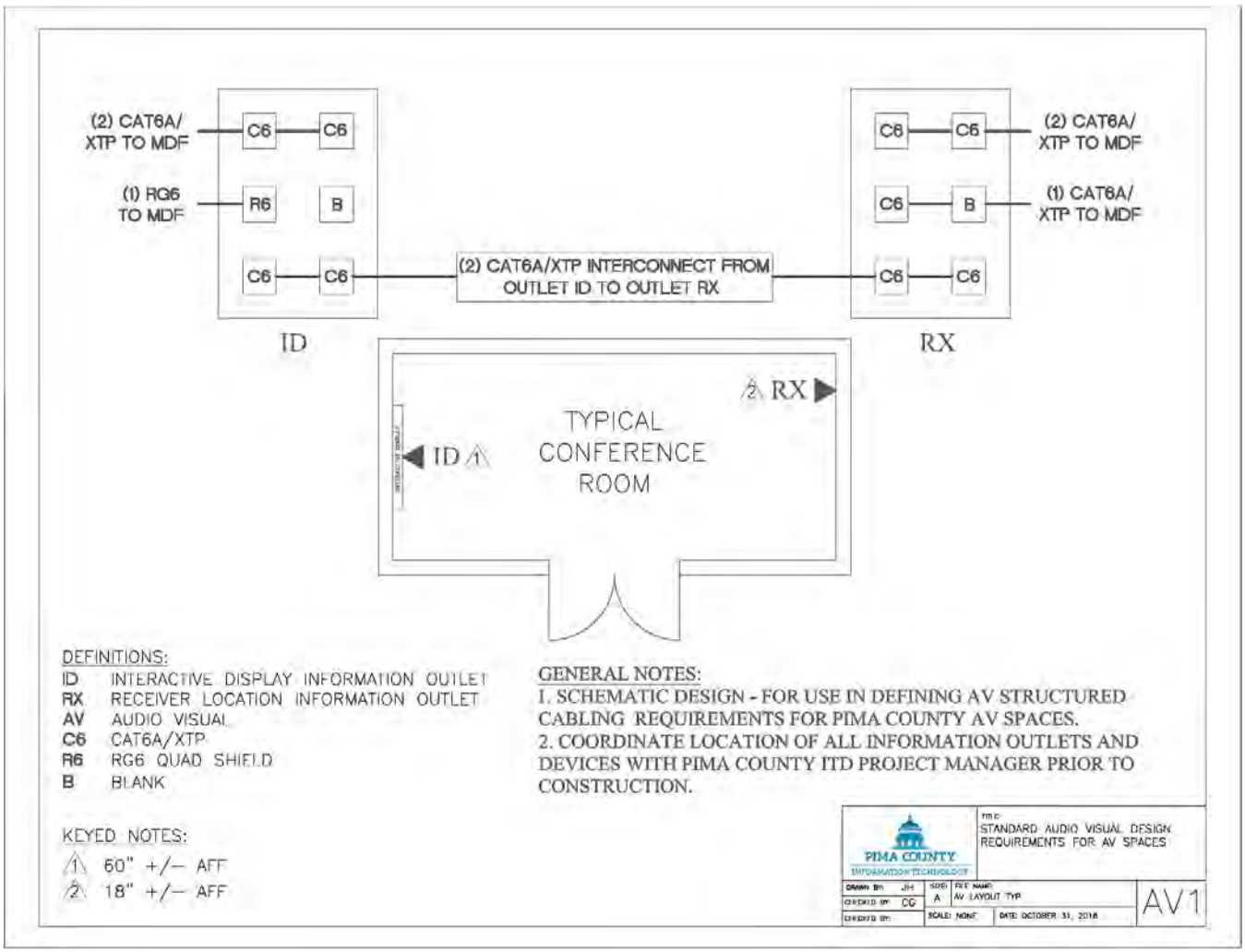

(2) CAT6A/ XTP TO MDF
(1) RG6 TO MDF
C6
R6
B
(2) CAT6A/XTP INTERCONNECT FROM OUTLET ID TO OUTLET RX
ID
RX
(1) CAT6A/ XTP TO MDF
TYPICAL CONFERENCE ROOM
2 RX
ID 1
DEFINITIONS:
ID INTERACTIVE DISPLAY INFORMATION OUTLET
RX RECEIVER LOCATION INFORMATION OUTLET
AV AUDIO VISUAL
C6 CAT6A/XTP
R6 RG6 QUAD SHIELD
B BLANK
KEYED NOTES:
1 60" +/- AFF
2 18" +/- AFF
GENERAL NOTES:
1. SCHEMATIC DESIGN - FOR USE IN DEFINING AV STRUCTURED CABLING REQUIREMENTS FOR PIMA COUNTY AV SPACES.
2. COORDINATE LOCATION OF ALL INFORMATION OUTLETS AND DEVICES WITH PIMA COUNTY ITD PROJECT MANAGER PRIOR TO CONSTRUCTION.
PIMA COUNTY
INFORMATION TECHNOLOGY
STANDARD AUDIO VISUAL DESIGN REQUIREMENTS FOR AV SPACES
DRAWN BY: JH
CHECKED BY: CG
SIZE: A
FILE NAME: AV LAYOUT TYP
SCALE: NONE
DATE: OCTOBER 31, 2018
AV1

Figure 1:

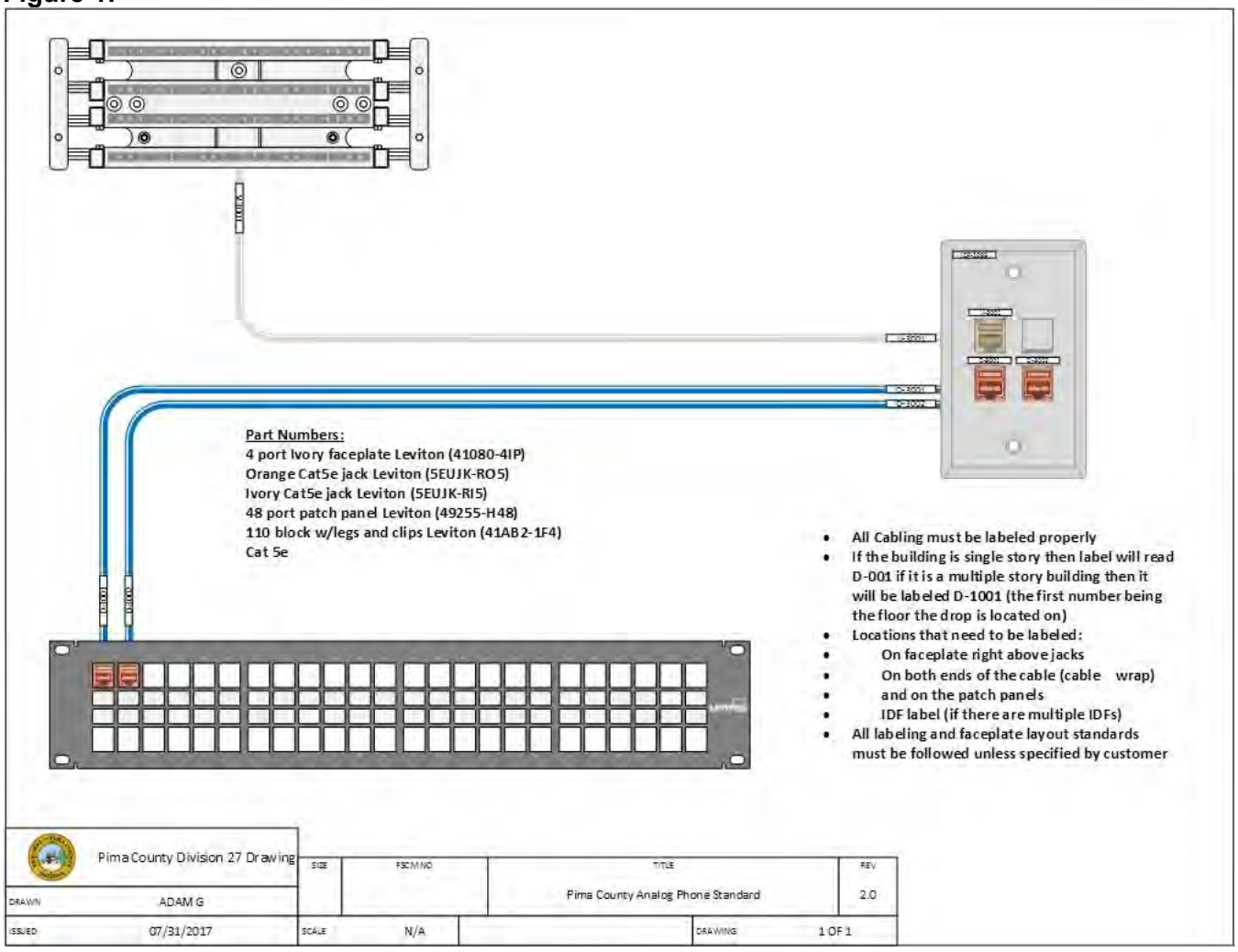

Part Numbers:
4 port Ivory faceplate Leviton (41080-4IP)
Orange Cat5e jack Leviton (5EUJK-RO5)
Ivory Cat5e jack Leviton (5EUJK-RI5)
48 port patch panel Leviton (49255-H48)
110 block w/legs and clips Leviton (41AB2-1F4)
Cat 5e
All Cabling must be labeled properly
If the building is single story then label will read D-001 if it is a multiple story building then it will be labeled D-1001 (the first number being the floor the drop is located on)
Locations that need to be labeled:
On faceplate right above jacks
On both ends of the cable (cable wrap)
and on the patch panels
IDF label (if there are multiple IDFs)
All labeling and faceplate layout standards must be followed unless specified by customer
Pima County Division 27 Drawing
SIZE
FSCM NO
TITLE
REV
Pima County Analog Phone Standard
2.0
DRAWN
ADAM G
ISSUED
07/31/2017
SCALE
N/A
DRAWING
1 OF 1

Figure 2:

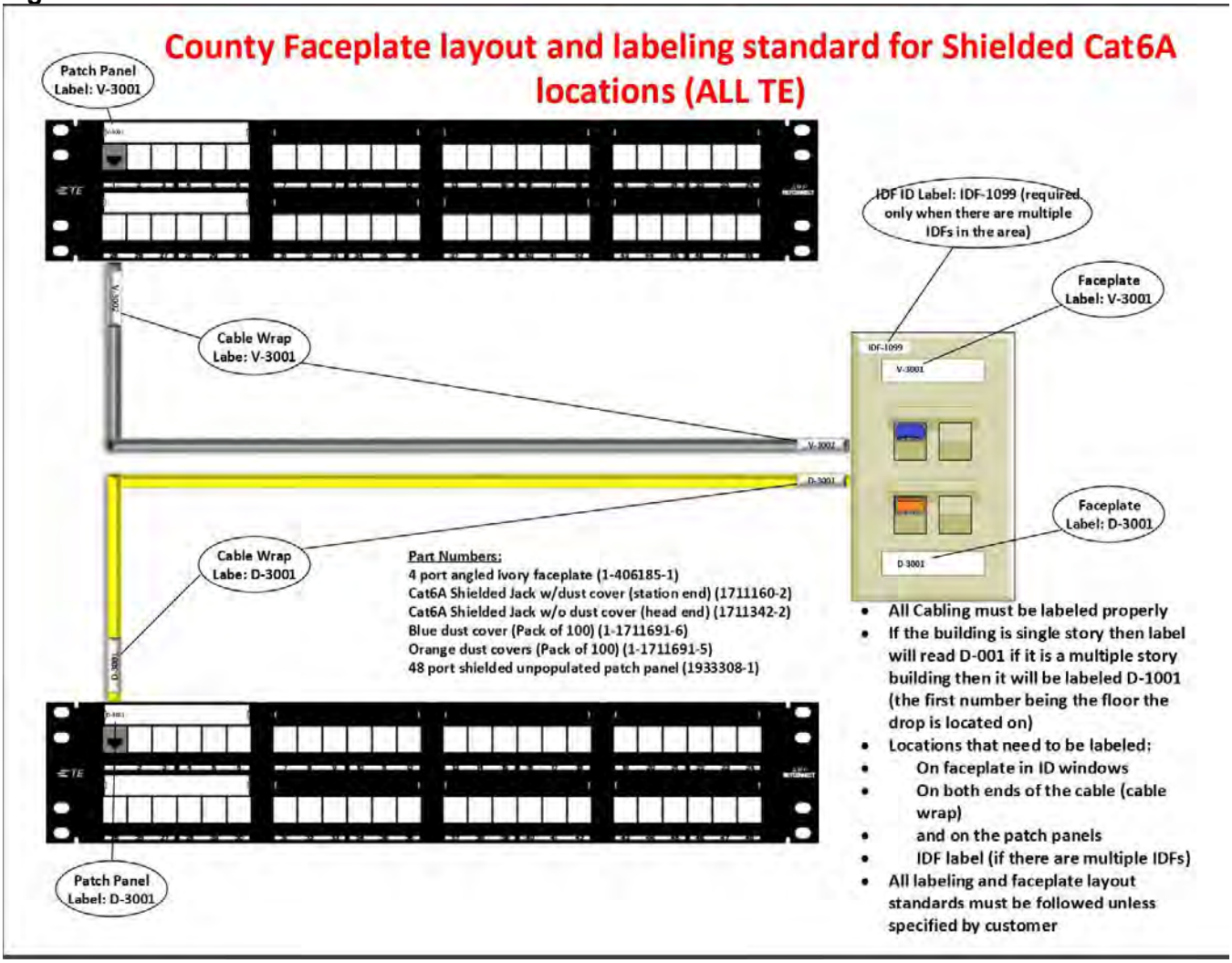

County Faceplate layout and labeling standard for Shielded Cat6A locations (ALL TE)
Patch Panel Label: V-3001
IDF ID Label: IDF-1099 (required only when there are multiple IDFs in the area)
Faceplate Label: V-3001
Cable Wrap Labe: V-3001
Cable Wrap Labe: D-3001
Faceplate Label: D-3001
Part Numbers:
4 port angled ivory faceplate (1-406185-1)
Cat6A Shielded Jack w/dust cover (station end) (1711160-2)
Cat6A Shielded Jack w/o dust cover (head end) (1711342-2)
Blue dust cover (Pack of 100) (1-1711691-6)
Orange dust covers (Pack of 100) (1-1711691-5)
48 port shielded unpopulated patch panel (1933308-1)
Patch Panel Label: D-3001
All Cabling must be labeled properly
If the building is single story then label will read D-001 if it is a multiple story building then it will be labeled D-1001 (the first number being the floor the drop is located on)
Locations that need to be labeled:
On faceplate in ID windows
On both ends of the cable (cable wrap)
and on the patch panels
IDF label (if there are multiple IDFs)
All labeling and faceplate layout standards must be followed unless specified by customer

Figure 3:

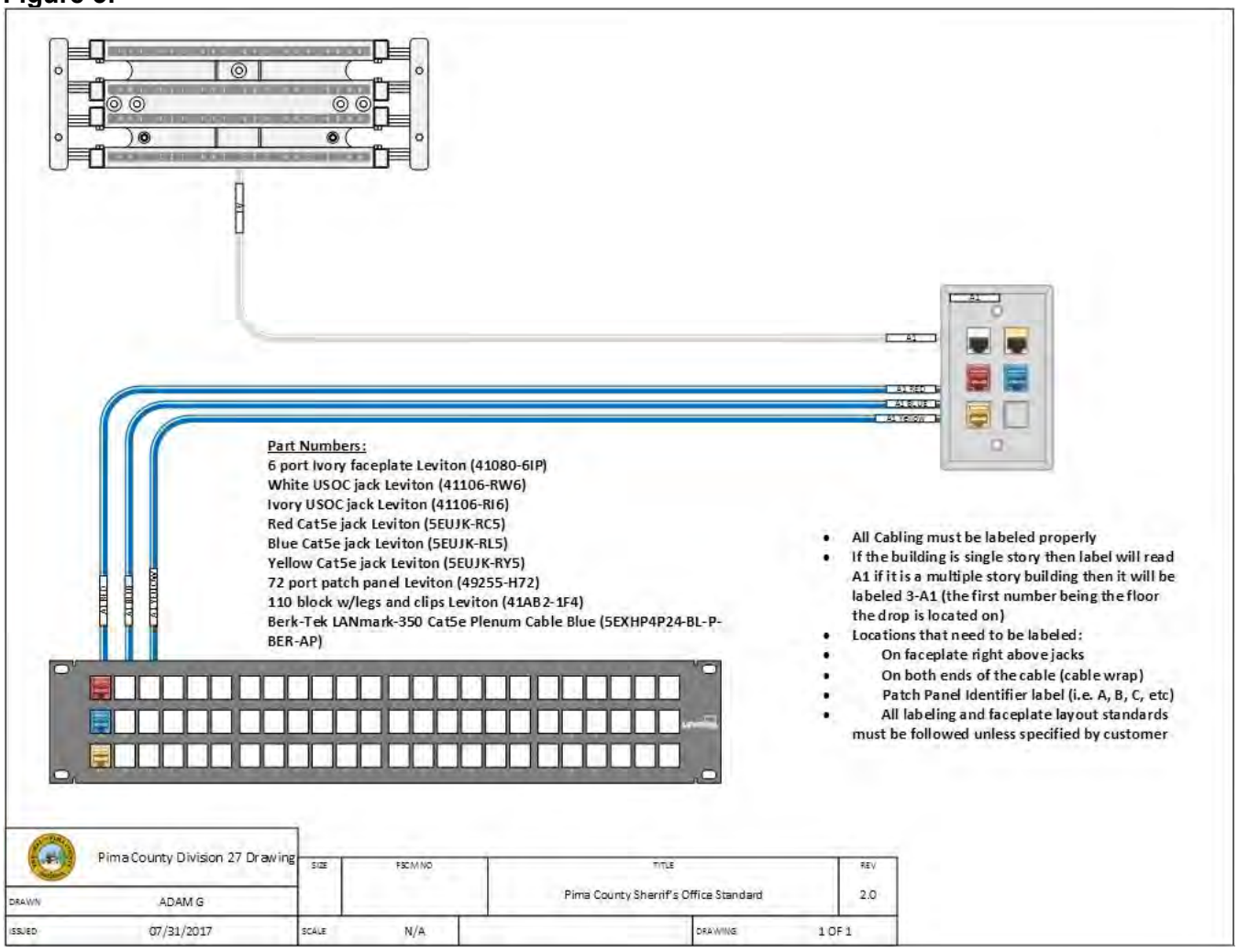

Part Numbers:
6 port Ivory faceplate Leviton (41080-6IP)
White USOC jack Leviton (41106-RW6)
Ivory USOC jack Leviton (41106-RI6)
Red Cat5e jack Leviton (5EUJK-RC5)
Blue Cat5e jack Leviton (5EUJK-RL5)
Yellow Cat5e jack Leviton (5EUJK-RY5)
72 port patch panel Leviton (49255-H72)
110 block w/legs and clips Leviton (41AB2-1F4)
Berk-Tek LANmark-350 Cat5e Plenum Cable Blue (5EXHP4P24-BL-P-BER-AP)
All Cabling must be labeled properly
If the building is single story then label will read A1 if it is a multiple story building then it will be labeled 3-A1 (the first number being the floor the drop is located on)
Locations that need to be labeled:
On faceplate right above jacks
On both ends of the cable (cable wrap)
Patch Panel Identifier label (i.e. A, B, C, etc)
All labeling and faceplate layout standards must be followed unless specified by customer
Pima County Division 27 Drawing
SIZE
FSCM NO
TITLE
Pima County Sheriff's Office Standard
REV
2.0
DRAWN
ADAM G
ISSUED
07/31/2017
SCALE
N/A
DRAWING
1 OF 1

Figure 4:

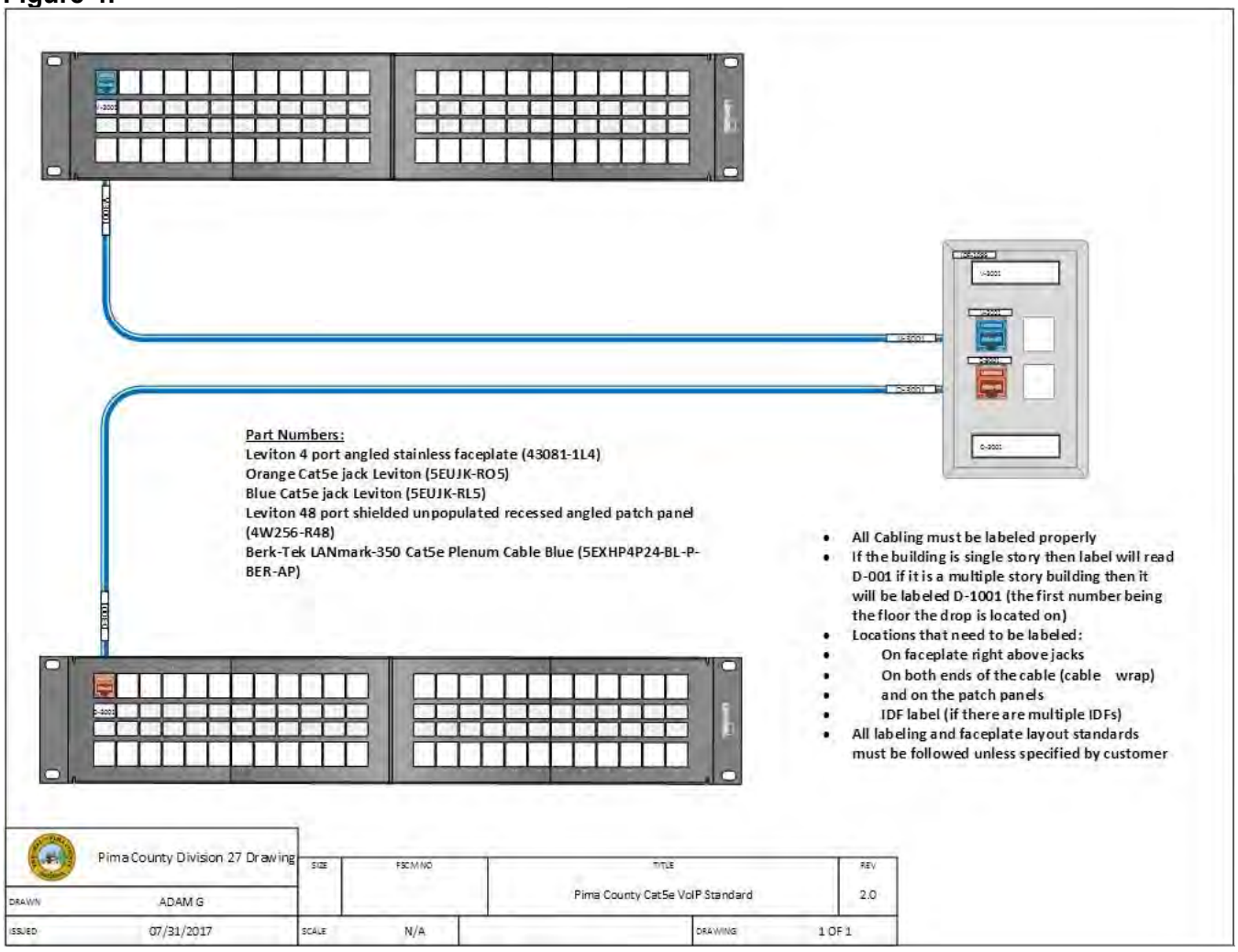

Part Numbers:
Leviton 4 port angled stainless faceplate (43081-1L4)
Orange Cat5e jack Leviton (5EUJK-RO5)
Blue Cat5e jack Leviton (5EUJK-RL5)
Leviton 48 port shielded unpopulated recessed angled patch panel (4W256-R48)
Berk-Tek LANmark-350 Cat5e Plenum Cable Blue (5EXHP4P24-BL-P-BER-AP)
All Cabling must be labeled properly
If the building is single story then label will read D-001 if it is a multiple story building then it will be labeled D-1001 (the first number being the floor the drop is located on)
Locations that need to be labeled:
On faceplate right above jacks
On both ends of the cable (cable wrap)
and on the patch panels
IDF label (if there are multiple IDFs)
All labeling and faceplate layout standards must be followed unless specified by customer
Pima County Division 27 Drawing
SIZE
FSCM NO
TITLE
Pima County Cat5e VoIP Standard
REV
2.0
DRAWN
ADAM G
ISSUED
07/31/2017
SCALE
N/A
DRAWING
1 OF 1

Figure 5:

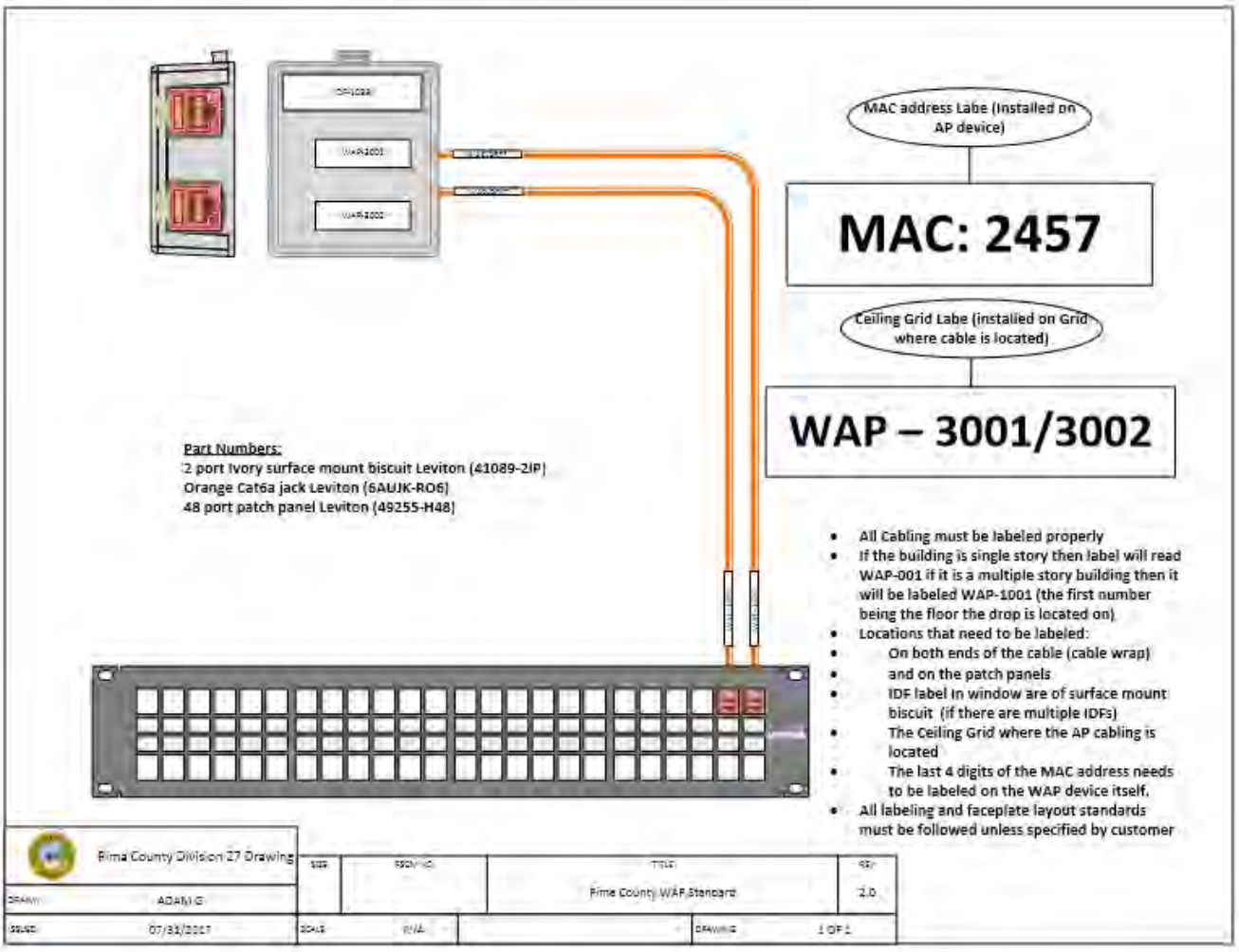

MAC address Labe (Installed on AP device)
MAC: 2457
Ceiling Grid Labe (installed on Grid where cable is located)
WAP – 3001/3002
Part Numbers:
2 port Ivory surface mount biscuit Leviton (41089-2IP)
Orange Cat6a jack Leviton (6AUJK-RO6)
48 port patch panel Leviton (49255-H48)
All Cabling must be labeled properly
If the building is single story then label will read WAP-001 if it is a multiple story building then it will be labeled WAP-1001 (the first number being the floor the drop is located on)
Locations that need to be labeled:
On both ends of the cable (cable wrap)
and on the patch panels
IDF label in window are of surface mount biscuit (if there are multiple IDFs)
The Ceiling Grid where the AP cabling is located
The last 4 digits of the MAC address needs to be labeled on the WAP device itself.
All labeling and faceplate layout standards must be followed unless specified by customer
Pima County Division 27 Drawing
Pima County WAP Standard
2.0
07/31/2017
1 OF 1

Figure 6:

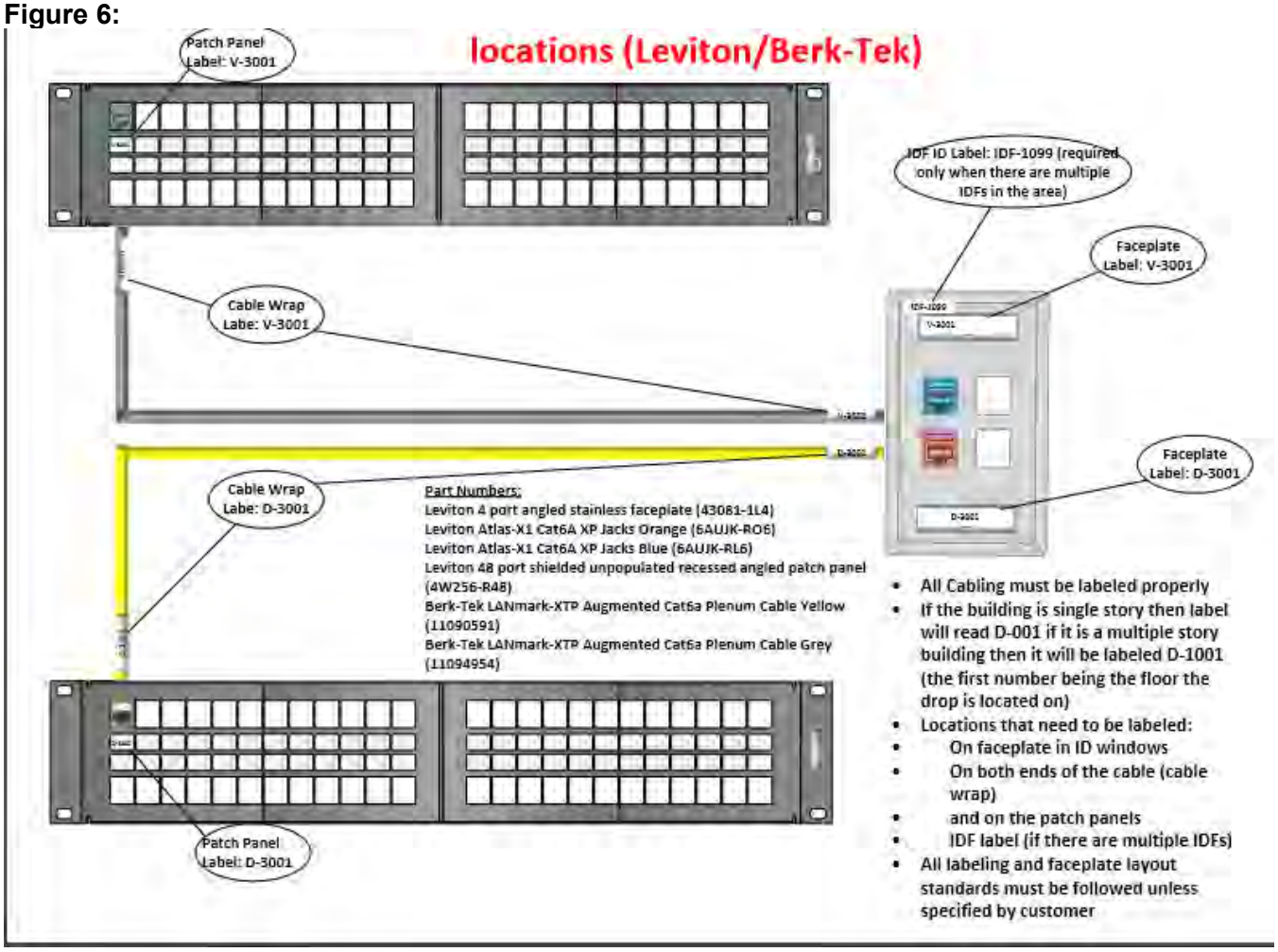

locations (Leviton/Berk-Tek)
Patch Panel Label: V-3001
IDF ID Label: IDF-1099 (required only when there are multiple IDFs in the area)
Faceplate Label: V-3001
Cable Wrap Labe: V-3001
Cable Wrap Labe: D-3001
Faceplate Label: D-3001
Part Numbers:
Leviton 4 port angled stainless faceplate (43081-1L4)
Leviton Atlas-X1 Cat6A XP Jacks Orange (6AUJK-RO6)
Leviton Atlas-X1 Cat6A XP Jacks Blue (6AUJK-RL6)
Leviton 48 port shielded unpopulated recessed angled patch panel (4W256-R48)
Berk-Tek LANmark-XTP Augmented Cat6a Plenum Cable Yellow (11090591)
Berk-Tek LANmark-XTP Augmented Cat6a Plenum Cable Grey (11094954)
Patch Panel Label: D-3001
All Cabling must be labeled properly
If the building is single story then label will read D-001 if it is a multiple story building then it will be labeled D-1001 (the first number being the floor the drop is located on)
Locations that need to be labeled:
On faceplate in ID windows
On both ends of the cable (cable wrap)
and on the patch panels
IDF label (if there are multiple IDFs)
All labeling and faceplate layout standards must be followed unless specified by customer

Figure 7:

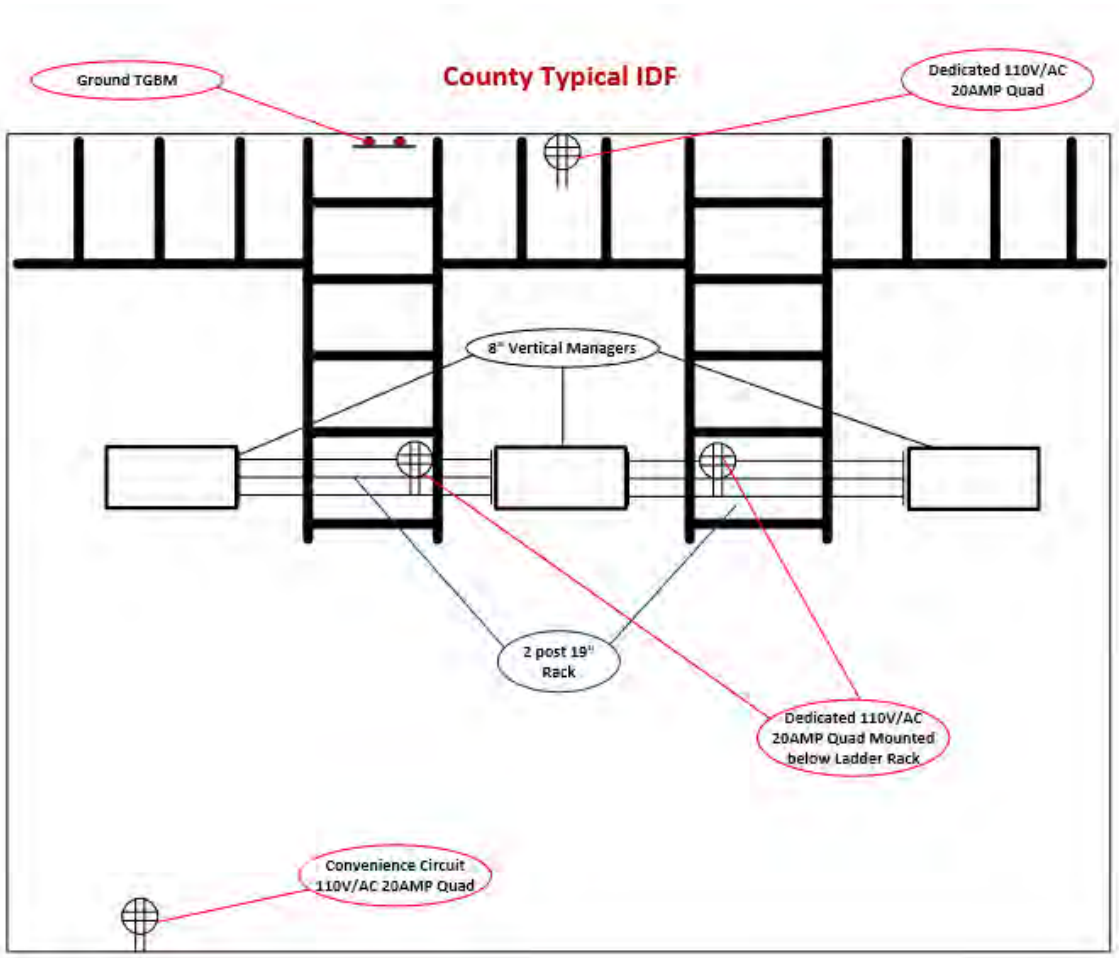

County Typical IDF
Ground TGBM
Dedicated 110V/AC 20AMP Quad
8" Vertical Managers
2 post 19" Rack
Dedicated 110V/AC 20AMP Quad Mounted below Ladder Rack
Convenience Circuit 110V/AC 20AMP Quad

Figure 8:

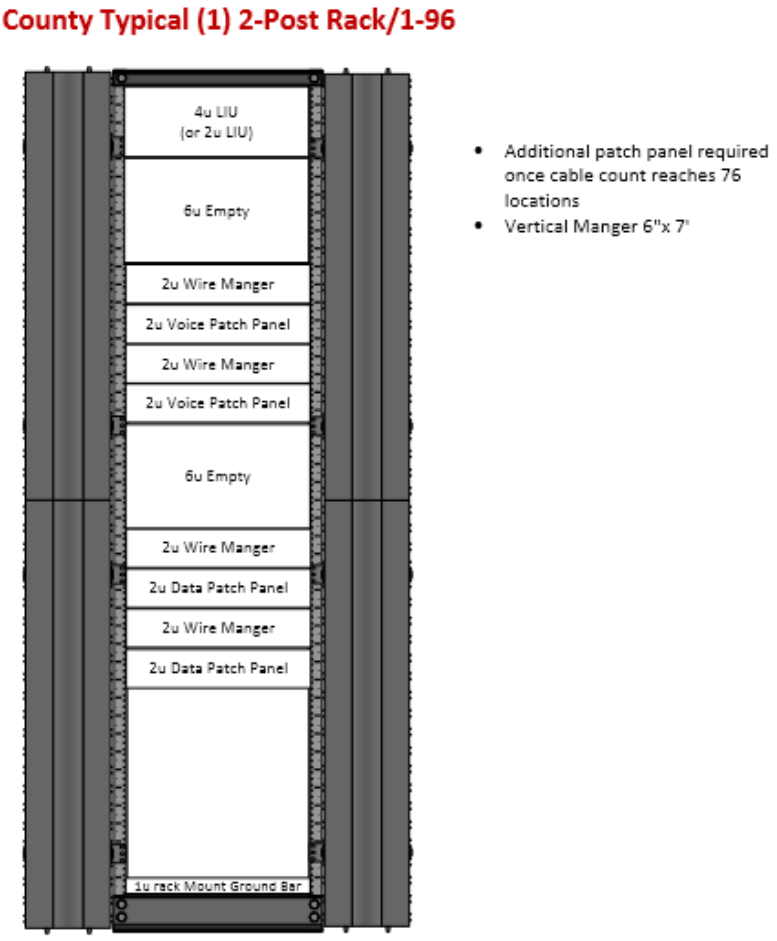
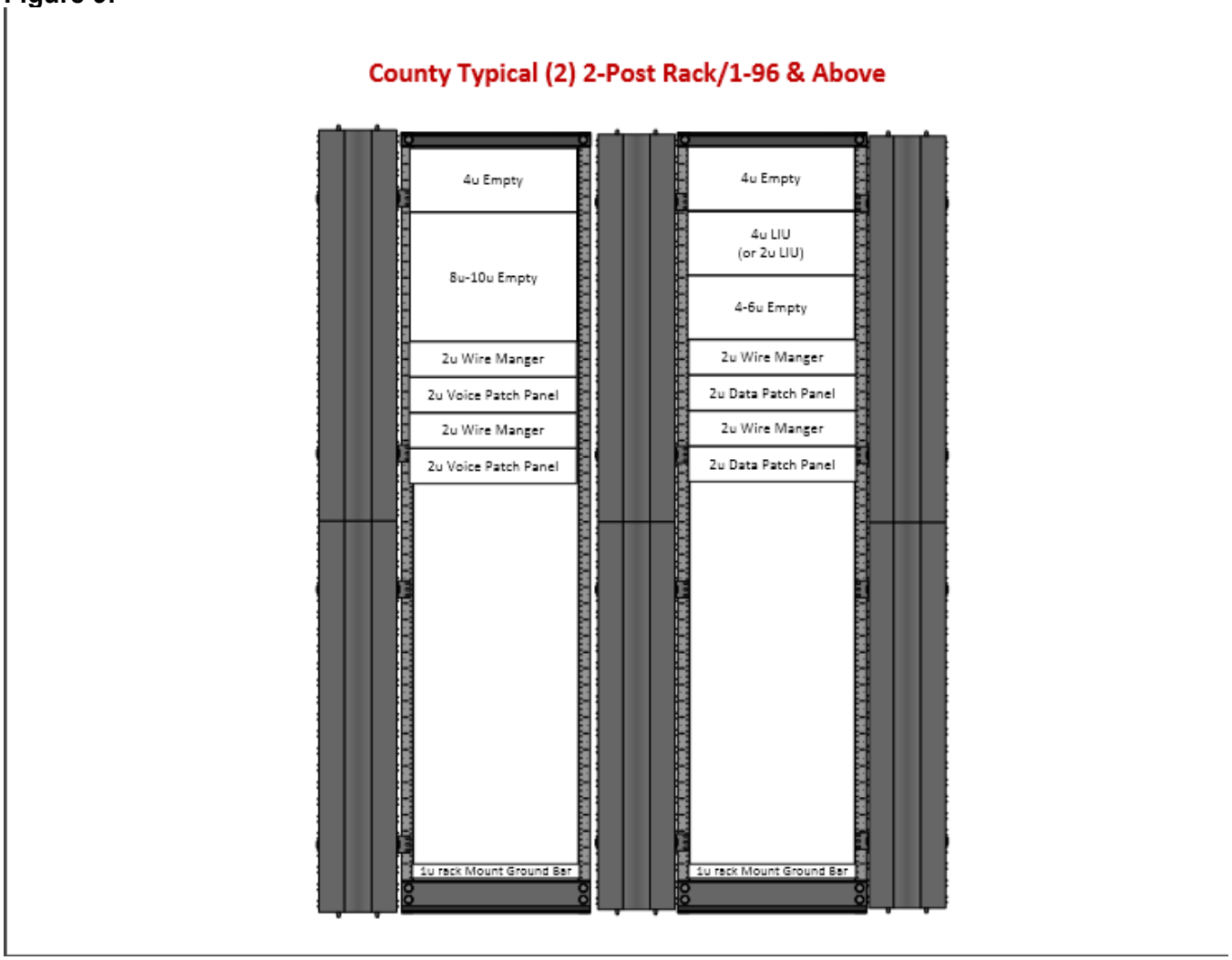

County Typical (1) 2-Post Rack/1-96
4u LIU
(or 2u LIU)
6u Empty
2u Wire Manger
2u Voice Patch Panel
2u Wire Manger
2u Voice Patch Panel
6u Empty
2u Wire Manger
2u Data Patch Panel
2u Wire Manger
2u Data Patch Panel
1u rack Mount Ground Bar
• Additional patch panel required once cable count reaches 76 locations
• Vertical Manger 6"x 7'

Figure 9:


County Typical (2) 2-Post Rack/1-96 & Above
4u Empty
8u-10u Empty
2u Wire Manger
2u Voice Patch Panel
2u Wire Manger
2u Voice Patch Panel
1u rack Mount Ground Bar
4u Empty
4u LIU
(or 2u LIU)
4-6u Empty
2u Wire Manger
2u Data Patch Panel
2u Wire Manger
2u Data Patch Panel
1u rack Mount Ground Bar

SECTION 280513 - CONDUCTORS AND CABLES FOR ELECTRONIC SAFETY AND SECURITY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Fire alarm wire and cable.
2. Identification products.

1.3 DEFINITIONS

A. EMI: Electromagnetic interference.

B. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control and signaling power-limited circuits.

C. Open Cabling: Passing telecommunications cabling through open space (e.g., between the studs of a wall cavity).

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified layout technician, installation supervisor, and field inspector.

B. Source quality-control reports.

C. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: An NRTL.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Test cables upon receipt at Project site.

1.8 FIELD CONDITIONS

A. Do not install conductors and cables that are wet, moisture damaged, or mold damaged.

1. Indications that wire and cables are wet or moisture damaged include, but are not limited to, discoloration and sagging of factory packing materials.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 50 or less.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 LOW-VOLTAGE CONTROL CABLE

A. Paired Cable: NFPA 70, Type CMG.

1. One pair, twisted, size as per fire alarm manufacturer tinned copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with UL 1581.

B. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.

1. One pair, twisted, size as per fire alarm manufacturer tinned copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with NFPA 262.

2.3 CONTROL-CIRCUIT CONDUCTORS

A. Class 1 Control Circuits: Stranded copper, Type THHN-THWN, complying with UL 83, in raceway.

B. Class 2 Control Circuits: Stranded copper, Type THHN-THWN, complying with UL 83, in raceway, power-limited cable, complying with UL 83, concealed in building finishes.

C. Class 3 Remote-Control and Signal Circuits: Stranded copper, Type TW or TF, complying with UL 83.

2.4 FIRE ALARM WIRE AND CABLE

A. Manufacturers: As recommended by fire alarm system manufacturer.

B. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.

C. Signaling Line Circuits: Twisted, shielded pair, as recommended by fire alarm manufacturer.

D. Non-Power-Limited Circuits: Solid-copper conductors with 600-V rated, 75 deg C, color-coded insulation.

2.5 IDENTIFICATION PRODUCTS

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

1. Brady Worldwide, Inc.
2. Hellermann Tyton North America.
3. Kroy LLC.
4. Panduit Corp.

B. Comply with UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

C. Comply with requirements in Section 260553 "Identification for Electrical Systems."

2.6 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate cables.

B. Cable will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for installation of supports for cables.

3.2 FIRE ALARM WIRING INSTALLATION

A. Comply with NECA 1 and NFPA 72.

B. Wiring Method: Install wiring in metal raceway according to Section 260533 "Raceways and Boxes for Electrical Systems."

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Fire alarm circuits and equipment control wiring associated with the fire alarm system shall be installed in a dedicated raceway system. This system shall not be used for any other wire or cable.
3. Cables and raceways used for fire alarm circuits, and equipment control wiring associated with the fire alarm system, may not contain any other wire or cable.
4. Fire-Rated Cables: Use of 2-hour, fire-rated fire alarm cables, NFPA 70, Types MI and CI, is permitted.
5. Signaling Line Circuits: Power-limited fire alarm cables may be installed in the same cable or raceway as signaling line circuits.

C. T-Tapping is not permitted:

D. Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by manufacturer. Install conductors parallel with or at right angles to sides and back of the enclosure. Bundle, lace, and train conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with the fire alarm system to terminal blocks. Mark each terminal according to the system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

E. Cable Taps: Use numbered terminal strips in junction, pull, and outlet boxes, cabinets, or equipment enclosures where circuit connections are made.

F. Color-Coding: Match existing Pima County color standards. Color-code fire alarm conductors differently from the normal building power wiring. Use one color-code for alarm circuit wiring and another for supervisory circuits. Color-code audible alarm-indicating circuits differently from alarm-initiating circuits. Use different colors for visible alarm-indicating devices. Paint fire alarm system junction boxes and covers red.

G. Risers: Install at least two vertical cable risers to serve the fire alarm system. Separate risers in close proximity to each other with a minimum one-hour-rated wall, so the loss of one riser does not prevent the receipt or transmission of signals from other floors or zones.

3.3 POWER AND CONTROL-CIRCUIT CONDUCTORS

A. 120-V Power Wiring: Install according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables" unless otherwise indicated.

B. Minimum Conductor Sizes:

1. Class 1 remote-control and signal circuits, No. 14 AWG.
2. Class 2 low-energy, remote-control and signal circuits, No. 16 AWG.
3. Class 3 low-energy, remote-control, alarm and signal circuits, No. 12 AWG.

3.4 CONNECTIONS

A. Comply with requirements in Section 283111 "Digital, Addressable Fire-Alarm System for connecting, terminating, and identifying wires and cables.

3.5 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

3.6 GROUNDING

A. For low-voltage wiring and cabling, comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.7 IDENTIFICATION

A. Identify system components, wiring, and cabling to match existing Pima County fire alarm requirements. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.8 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.

C. Document data for each measurement. Transfer the data from the instrument to the computer, save as text files, print, and submit.

D. End-to-end cabling will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

END OF SECTION 280513

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 283111 - DIGITAL, ADDRESSABLE FIRE ALARM SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Manual fire-alarm boxes.
2. System smoke detectors.
3. Notification appliances.
4. Addressable interface device.

B. Related Requirements:

1. Section 280513 "Conductors and Cables for Electronic Safety and Security" for cables and conductors for fire-alarm systems.

1.3 DEFINITIONS

A. EMT: Electrical Metallic Tubing.

B. FACP: Fire Alarm Control Panel.

C. NICET: National Institute for Certification in Engineering Technologies.

D. PC: Personal computer.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product, including furnished options and accessories.

1. Include construction details, material descriptions, dimensions, profiles, and finishes.
2. Include rated capacities, operating characteristics, and electrical characteristics.

B. Shop Drawings: For fire-alarm system.

1. Comply with recommendations and requirements in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
2. Include plans, elevations, sections, details, and attachments to other work.
3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and locations. Indicate conductor sizes, indicate termination locations and requirements, and distinguish between factory and field wiring.

4. Detail assembly and support requirements.
5. Include voltage drop calculations for notification-appliance circuits.
6. Include battery-size calculations.
7. Include input/output matrix.
8. Include statement from manufacturer that all equipment and components have been tested as a system and meet all requirements in this Specification and in NFPA 72.
9. Include performance parameters and installation details for each detector.
10. Verify that each duct detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
11. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale; coordinate location of duct smoke detectors and access to them.

    a. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators.
    b. Show field wiring required for HVAC unit shutdown on alarm.
    c. Locate detectors according to manufacturer's written recommendations.

12. Include alarm signaling-service console layout, grounding schematic, and single-line connection diagram.
13. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits and point-to-point wiring diagrams.

C. General Submittal Requirements:

1. Submittals shall be approved by authorities having jurisdiction prior to submitting them to Architect.
2. Shop Drawings shall be prepared by persons with the following qualifications:

    a. Trained and certified by manufacturer in fire-alarm system design.
    b. NICET-certified, fire-alarm technician; [Level III] [Level IV] minimum.
    c. Licensed or certified by authorities having jurisdiction.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following and deliver copies to authorities having jurisdiction:

    a. Comply with the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
    b. Provide "Fire Alarm and Emergency Communications System Record of Completion Documents" according to the "Completion Documents" Article in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.

c. Complete wiring diagrams showing connections between all devices and equipment. Each conductor shall be numbered at every junction point with indication of origination and termination points.
d. Riser diagram.
e. Device addresses.
f. Record copy of site-specific software.
g. Provide "Inspection and Testing Form" according to the "Inspection, Testing and Maintenance" chapter in NFPA 72, and include the following:

1) Equipment tested.
2) Frequency of testing of installed components.
3) Frequency of inspection of installed components.
4) Requirements and recommendations related to results of maintenance.
5) Manufacturer's user training manuals.

h. Manufacturer's required maintenance related to system warranty requirements.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On magnetic media or compact disk, complete with data files.
3. Device address list.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lamps for Remote Indicating Lamp Units: Quantity equal to 10 percent of amount installed, but no fewer than one unit.
2. Lamps for Strobe Units: Quantity equal to 10 percent of amount installed, but no fewer than one unit.
3. Smoke Detectors, Fire Detectors and Heat Detectors: Quantity equal to 10 percent of amount of each type installed, but no fewer than one unit of each type.
4. Detector Bases: Quantity equal to two percent of amount of each type installed, but no fewer than one unit of each type.
5. Keys and Tools: One extra set for access to locked or tamperproofed components.
6. Audible and Visual Notification Appliances: One of each type installed.
7. Fuses: Two of each type installed in the system. Provide in a box or cabinet with compartments marked with fuse types and sizes.

1.8 QUALITY ASSURANCE

A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.

B. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level II technician.

1.9 PROJECT CONDITIONS

A. Perform a full test of the existing system prior to starting work. Document any equipment, components or wiring not functioning as designed.

B. Interruption of Existing Fire-Alarm Service: Do not interrupt fire-alarm service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary guard service according to requirements indicated:

1. Notify Architect, Construction Manager and Owner no fewer than seven days in advance of proposed interruption of fire-alarm service.
2. Do not proceed with interruption of fire-alarm service without Owner's written permission.

C. Use of Devices during Construction: Protect devices during construction unless devices are placed in service to protect the facility during construction.

1.10 SEQUENCING AND SCHEDULING

A. Existing Fire-Alarm Equipment: Maintain existing equipment fully operational until new equipment has been tested and accepted. As new equipment is installed, label it "NOT IN SERVICE" until it is accepted. Remove labels from new equipment when put into service, and label existing fire-alarm equipment "NOT IN SERVICE" until removed from the building.

B. Equipment Removal: After acceptance of new fire-alarm system, remove existing disconnected fire-alarm equipment and wiring.

1.11 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace fire-alarm system equipment and components that fail in materials or workmanship within specified warranty period.

1. Warranty Extent: All equipment and components not covered in the Maintenance Service Agreement.
2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Source Limitations for Fire-Alarm System and Components: Components shall be compatible with, and operate as an extension of, existing Simplex Grinnell system. Provide system manufacturer's certification that all components provided have been tested as, and will operate as, a system.

B. All components provided shall be listed for use with the selected system.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 SYSTEMS OPERATIONAL DESCRIPTION

A. Fire-alarm signal initiation shall be by one or more of the following devices and systems:

1. Manual stations.
2. Smoke detectors.
3. Duct smoke detectors.
4. Automatic sprinkler system water flow.
5. Fire-extinguishing system operation.
6. Fire standpipe system.
7. Fire pump running.

B. Fire-alarm signal shall initiate the following actions:

1. Continuously operate alarm notification appliances.
2. Identify alarm and specific initiating device at fire-alarm control unit connected network control panels, off-premises network control panels and remote annunciators.
3. Transmit an alarm signal to the remote alarm receiving station.
4. Unlock electric door locks in designated egress paths.
5. Release fire and smoke doors held open by magnetic door holders.
6. Activate alarm communication system.
7. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode.
8. Close smoke dampers in air ducts of designated air-conditioning duct systems.
9. Recall elevators to primary or alternate recall floors.
10. Activate elevator power shunt trip.
11. Record events in the system memory.
12. Indicate device in alarm on the annunciator.

C. Supervisory signal initiation shall be by one or more of the following devices and actions:

1. Valve supervisory switch.
2. Elevator shunt-trip supervision.
3. Fire pump running.
4. Fire-pump loss of power.
5. Fire-pump power phase reversal.
6. Independent fire-detection and -suppression systems.
7. User disabling of zones or individual devices.
8. Loss of communication with any panel on the network.

D. System trouble signal initiation shall be by one or more of the following devices and actions:

1. Open circuits, shorts, and grounds in designated circuits.
2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
3. Loss of communication with any addressable sensor, input module, relay, control module, remote annunciator, printer interface, or Ethernet module.
4. Loss of primary power at fire-alarm control unit.
5. Ground or a single break in internal circuits of fire-alarm control unit.
6. Abnormal ac voltage at fire-alarm control unit.
7. Break in standby battery circuitry.
8. Failure of battery charging.
9. Abnormal position of any switch at fire-alarm control unit or annunciator.

E. System Supervisory Signal Actions:

1. Identify specific device initiating the event at fire-alarm control unit connected network control panels, off-premises network control panels, and remote annunciators.
2. Record the event on system in system memory.
3. Display system status on annunciator.

2.3 FIRE-ALARM CONTROL UNIT

A. Manufacturers: Existing Simplex Grinnell 4100.

B. Initiating-Device, Notification-Appliance, and Signaling-Line Circuits:

1. Pathway Class Designations: NFPA 72, Class A.
2. Maintain 25 percent space capacity on each signaling-line circuit.

C. Smoke-Alarm Verification:

1. Initiate audible and visible indication of an "alarm-verification" signal at fire-alarm control unit.
2. Activate an approved "alarm-verification" sequence at fire-alarm control unit and detector.
3. Record events by the system printer.
4. Sound general alarm if the alarm is verified.
5. Cancel fire-alarm control unit indication and system reset if the alarm is not verified.

D. Notification-Appliance Circuit:

1. Audible appliances shall sound in a three-pulse temporal pattern, as defined in NFPA 72.
2. Notification appliance alarm signals shall be a 520-Hz square wave with an intensity 15 dB above the average ambient sound level or 5 dB above the maximum sound level, or at least 75 dBA, whichever is greater, measured at the pillow.
3. Visual alarm appliances shall flash in synchronization where multiple appliances are in the same field of view, as defined in NFPA 72.

E. Elevator Recall:

1. Elevator recall shall be initiated only by one of the following alarm-initiating devices:

   a. Elevator lobby detectors except the lobby detector on the designated floor.
   b. Smoke detector in elevator machine room.
   c. Smoke detectors in elevator hoistway.

2. Elevator controller shall be programmed to move the cars to the alternate recall floor if lobby detectors located on the designated recall floors are activated.
3. Water-flow alarm connected to sprinkler in an elevator shaft and elevator machine room shall shut down elevators associated with the location without time delay.

F. Door Controls: Door hold-open devices that are controlled by smoke detectors at doors in smoke-barrier walls shall be connected to fire-alarm system.

G. Printout of Events: On receipt of signal, print alarm, supervisory, and trouble events. Identify zone, device, and function. Include type of signal (alarm, supervisory, or trouble) and date and time of occurrence. Differentiate alarm signals from all other printed indications. Also print system reset event, including same information for device, location, date, and time. Commands initiate the printing of a list of existing alarm, supervisory, and trouble conditions in the system and a historical log of events.

H. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, and supervisory signals shall be powered by 24-V dc source.

1. Alarm current draw of entire fire-alarm system shall not exceed 80 percent of the power-supply module rating.

I. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.

1. Batteries: To match existing

2.4 MANUAL FIRE-ALARM BOXES (Simplex #4099-9006)

A. Manufacturers: Subject to compliance with requirements:

B. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.

1. Double-action mechanism requiring two actions to initiate an alarm pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.
2. Station Reset: Key- or wrench-operated switch.

2.5 SYSTEM SMOKE DETECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. SimplexGrinnell LP.

B. General Requirements for System Smoke Detectors:

1. Comply with UL 268; operating at 24-V dc, nominal.
2. Detectors shall be two-wire type.
3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
4. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
5. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
6. Integral Visual-Indicating Light: LED type, indicating detector has operated and power-on status.

7. Remote Control: Unless otherwise indicated, detectors shall be digital-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by fire-alarm control unit.

    a. Rate-of-rise temperature characteristic of combination smoke- and heat-detection units shall be selectable at fire-alarm control unit for 15 or 20 deg F per minute.
    b. Fixed-temperature sensing characteristic of combination smoke- and heat-detection units shall be independent of rate-of-rise sensing and shall be settable at fire-alarm control unit to operate at 135 or 155 deg F.

C. Photoelectric Smoke Detectors (Simplex #4098-9714):

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

    a. Primary status.
    b. Device type.
    c. Present average value.
    d. Present sensitivity selected.
    e. Sensor range (normal, dirty, etc.).

D. Duct Smoke Detectors: Photoelectric type complying with UL 268A (Simplex #4098-9756)

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

    a. Primary status.
    b. Device type.
    c. Present average value.
    d. Present sensitivity selected.
    e. Sensor range (normal, dirty, etc.).

3. Each sensor shall have multiple levels of detection sensitivity.
4. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
5. Relay Fan Shutdown: Relay rated to interrupt fan motor-control circuit.

2.6 NOTIFICATION APPLIANCES

A. General Requirements for Notification Appliances: Connected to notification-appliance signal circuits, zoned per floor as indicated, equipped for mounting as indicated, and with screw terminals for system connections.

1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated, and with screw terminals for system connections.

B. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464. Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet from the horn, using the coded signal prescribed in UL 464 test protocol.

C. Visible Notification Appliances (Simplex 4906-9101): Xenon strobe lights complying with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch- high letters on the lens.

1. Rated Light Output:

a. 15/30/75/110 CD, selectable in the field.

2. Mounting: Wall mounted unless otherwise indicated.
3. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
4. Flashing shall be in a temporal pattern, synchronized with other units.
5. Strobe Leads: Factory connected to screw terminals.
6. Mounting Faceplate: Factory finished, red for wall mounted devices and red for ceiling mounted devices.

2.7 ADDRESSABLE RELAY MODULES

A. Provide address-setting means on the module. Store an internal identifying code for control panel use to identify the module type.

B. Allow the control panel to switch the relay contacts on command.

C. Have a minimum of two normally open and two normally closed contacts available for field wiring.

D. Listed for controlling HVAC fan motor controllers.

2.8 ADDRESSABLE INTERFACE DEVICE

A. General:

1. Include address-setting means on the module.
2. Store an internal identifying code for control panel use to identify the module type.
3. Listed for controlling HVAC fan motor controllers.

B. Monitor Module: Microelectronic module providing a system address for alarm-initiating devices for wired applications with normally open contacts.

C. Integral Relay: Capable of providing a direct signal.

1. Allow the control panel to switch the relay contacts on command.
2. Have a minimum of two normally open and two normally closed contacts available for field wiring.

D. Control Module:

1. Operate devices as required.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance of the Work.

1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment and wiring are installed, before installation begins.

B. Examine roughing-in for electrical connections to verify actual locations of connections before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EQUIPMENT INSTALLATION

A. Comply with NFPA 72, NFPA 101, and requirements of authorities having jurisdiction for installation and testing of fire-alarm equipment. Install all electrical wiring to comply with requirements in NFPA 70 including, but not limited to, Article 760, "Fire Alarm Systems."

1. Devices placed in service before all other trades have completed cleanup shall be replaced.
2. Devices installed but not yet placed in service shall be protected from construction dust, debris, dirt, moisture, and damage according to manufacturer's written storage instructions.

B. Connecting to Existing Equipment: Verify that existing fire-alarm system is operational before making changes or connections.

1. Connect new equipment to existing control panel in existing part of the building.
2. Connect new equipment to existing monitoring equipment at the supervising station.
3. Expand, modify, and supplement existing control and monitoring equipment as necessary to extend existing control and monitoring functions to the new points. New components shall be capable of merging with existing configuration without degrading the performance of either system.

C. Install wall-mounted equipment, with tops of cabinets not more than 78 inches above the finished floor.

1. Comply with requirements for seismic-restraint devices specified in Section 260548 "Vibration and Seismic Controls for Electrical Systems."

D. Manual Fire-Alarm Boxes:

1. Install manual fire-alarm box in the normal path of egress within 60 inches of the exit doorway.
2. Mount manual fire-alarm box on a background of a contrasting color.
3. The operable part of manual fire-alarm box shall be between 42 inches and 48 inches above floor level. All devices shall be mounted at the same height unless otherwise indicated.

E. Smoke- or Heat-Detector Spacing:

1. Comply with the "Smoke-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for smoke-detector spacing.
2. Comply with the "Heat-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for heat-detector spacing.
3. Smooth ceiling spacing shall not exceed 30 feet.
4. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to Annex A in NFPA 72.
5. HVAC: Locate detectors not closer than 36 inches from air-supply diffuser or return-air opening.
6. Lighting Fixtures: Locate detectors not closer than 12 inches from any part of a lighting fixture and not directly above pendant mounted or indirect lighting.

F. Install a cover on each smoke detector that is not placed in service during construction. Cover shall remain in place except during system testing. Remove cover prior to system turnover.

G. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct. Tubes more than 36 inches long shall be supported at both ends.

1. Do not install smoke detector in duct smoke-detector housing during construction. Install detector only during system testing and prior to system turnover.

H. Remote Status and Alarm Indicators: Install flush in wall a visible location near each smoke detector, sprinkler water-flow switch, and valve-tamper switch that is not readily visible from normal viewing position.

I. Audible Alarm-Indicating Devices: Install not less than 6 inches below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille. Install all devices at the same height unless otherwise indicated.

J. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inches below the ceiling. Install all devices at the same height unless otherwise indicated.

K. Device Location-Indicating Lights: Locate in public space near the device they monitor.

3.3 PATHWAYS

A. Pathways shall be installed in EMT.

B. Exposed EMT above accessible ceiling and in non-accessible ceilings shall be painted red enamel.

3.4 CONNECTIONS

A. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Section 087100 "Door Hardware." Connect hardware and devices to fire-alarm system.

1. Verify that hardware and devices are listed for use with installed fire-alarm system before making connections.

B. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 36 inches from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.

1. Smoke dampers in air ducts of designated HVAC duct systems.
2. Electronically locked doors and access gates.
3. Alarm-initiating connection to elevator recall system and components.
4. Supervisory connections at valve supervisory switches.

3.5 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical System," and to match Pima County device and cabling standards.

3.6 GROUNDING

A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.

B. Ground shielded cables at the control panel location only. Insulate shield at device location.

3.7 FIELD QUALITY CONTROL

A. Field tests shall be witnessed by authorities having jurisdiction.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

D. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Visual Inspection: Conduct visual inspection prior to testing.

    a. Inspection shall be based on completed record Drawings and system documentation that is required by the "Completion Documents, Preparation" table in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
    b. Comply with the "Visual Inspection Frequencies" table in the "Inspection" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.

2. System Testing: Comply with the "Test Methods" table in the "Testing" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
3. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.

4. Test audible appliances for the private operating mode according to manufacturer's written instructions.
5. Test visible appliances for the public operating mode according to manufacturer's written instructions.
6. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" section of the "Fundamentals" chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

E. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.

F. Fire-alarm system will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

H. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

3.8 SOFTWARE SERVICE AGREEMENT

A. Comply with UL 864.

B. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

C. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule access to system and to upgrade computer equipment if necessary.

3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fire-alarm system.

END OF SECTION 283111

THIS PAGE INTENTIONALLY LEFT BLANK