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SECTION 15030

PIPING AND EQUIPMENT IDENTIFICATION SYSTEMS

PART 1 – GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish and install all components of the system for identification of piping and equipment as specified hereinafter. The system shall include the application of color coding to all new and altered plant piping. The Contractor shall paint the equipment and piping of all Contracts in the colors herein specified, and in accordance with the requirements of Section 09900 – Painting.

B. In addition to the legends specified herein, the Engineer may order the Contractor to furnish and install additional identification legends and arrows at no additional cost to the Owner. Such additional signs may be requested near completion of the work and shall be limited to no more than five (5) signs for each type specified herein. The legends and color combinations for additional signs shall conform to the requirements specified herein.

C. The Contractor shall submit a schedule of the colors and designations proposed in accordance with Section 01300 – Submittals and this Section. A minimum of four (4) color charts with cross-references to the colors listed herein shall be included with the Submittal.

D. Reference Section 15000 – Basic Mechanical Requirements.

PART 2 – PRODUCTS

2.01 PIPING BAND

A. All new and altered piping shall receive identification bands. Such bands shall be 6-inches wide, neatly made by masking, and spaced at intervals of 30-inches on centers regardless of the diameter of the pipe being painted. The Contractor may use approved precut and prefinished metal bands on piping, in lieu of the masked and painted bands, where approved by the Engineer.

2.02 PIPING IDENTIFICATION LEGEND

A. The Contractor shall apply identification legends to all types and sections of piping as shown on the Drawings or as designated by the Engineer. Such legends shall be in the form of plain block lettering giving the name of the pipe content in full or abbreviated form and showing the direction of flow by arrows. All lettering and arrows shall be of the plastic snap-on type, Seton nameplate "setmarks", or equal, or they shall be formed by stenciling in an approved manner using white or black as directed and shall have an overall height in inches in accordance with the following table:

Diameter of Pipe or Pipe Covering	Height of Lettering
3/4 to 1-1/4 inches	1/2-inches
1-1/2 to 2-inches	3/4-inches
2-1/2 to 6-inches	1-1/4-inches
8 to 10-inches	2-1/2-inches
Over 10-inches	3-1/2-inches

B. Identification lettering shall be located midway between color coding bands where possible. Identification lettering and arrows shall be placed as directed by the Engineer, but shall generally be located each fifteen (15) feet in pipe length, and shall be properly inclined to the pipe axis to facilitate easy reading. In the event lettering and arrow identifications are required for piping less than 3/4-inch in diameter, the Contractor shall furnish and attach approved color-coded tags where instructed.

C. All piping shall be painted in accordance with Section 09900 using color coding below. The colors referenced are generic with final color selection to be made by the Owner based on physical color charts submitted for this purpose.

D. Piping and Equipment Identification

Service	Legend	Pipe Color
Sanitary and Process Drains	Drain	Grey
Process Air	Process Air	Dark Green
Potable Cold Water	Potable Water	Light Blue
Potable Hot Water	Potable Water-Hot	Light Blue
Nonpotable Water	Nonpotable Water	Light Green
Alum	Alum	Not Painted

PART 3 – EXECUTION (NOT USED)

- END OF SECTION -

SECTION 15075

IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:

1. Equipment labels.

2. Pipe labels.

3. Duct labels.

4. Valve tags.

1.03 ACTION SUBMITTALS

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

B. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

C. Valve numbering scheme.

D. Valve Schedules: For each piping system to include in maintenance manuals.

1.04 COORDINATION

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 1 - PRODUCTS

1.05 EQUIPMENT LABELS

A. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.

2. Letter Color: White.

3. Background Color: Black.

4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

7. Fasteners: Stainless-steel rivets or self-tapping screws.

8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules).

C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

1.06 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

B. Pretensioned Pipe Labels: Pre-coiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

C. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.

2. Lettering Size: At least 1-1/2 inches.

1.07 DUCT LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.

B. Letter Color: White.

C. Background Color: Per section 3.4.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

E. Minimum Label Size: Length and width vary for required label content, but not less than 4 by 2-4 inch.

F. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

G. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings, duct size, and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions, or as separate unit on each duct label to indicate flow direction.

2. Lettering Size: At least 1-1/2 inches.

1.08 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.

1. Tag Material: Brass, 0.032-inch or anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.

2. Fasteners: Brass wire-link or beaded chain; or S-hook.

B. Valve Schedules and Diagram: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Provide diagram of all valves in system on 11-by-17-inch bond paper. Mark valves for emergency shutoff and similar special uses.

1. Valve-tag schedule shall be included in operation and maintenance data.

PART 2 - EXECUTION

1.09 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

1.10 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

C. When equipment is located above the ceiling install label on the ceiling grid T-bar below the equipment and on equipment.

D. For all thermostats provide a label which clearly indicates what HVAC system is associated with the thermostat

1.11 PIPE LABEL INSTALLATION

A. Piping Color-Coding: Painting of piping is specified in Division 09.

B. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.

2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.

3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.

4. At access doors, manholes, and similar access points that permit view of concealed piping.

5. Near major equipment items and other points of origination and termination.

6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.

7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

C. Pipe Label Color Schedule:

1. Refrigerant Piping:

    a. Background Color: Black.

    b. Letter Color: White

1.12 DUCT LABEL INSTALLATION

A. Install duct labels with permanent adhesive on air ducts in the following color codes:

1. Blue: For cold-air supply ducts.

2. Yellow: For hot-air supply ducts.

3. Green: For exhaust-, outside-, relief-, return-, and mixed-air ducts.

4. ASME A13.1 Colors and Designs: For hazardous material exhaust.

B. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

1.13 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections; and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:

1. Valve-Tag Size and Shape: 1-1/2 inches, round.

    a. Valve-Tag Color: Natural.

    b. Letter Color: Black.

END OF SECTION

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SECTION 15082

THERMAL INSULATION FOR DUCTING

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section includes insulating the following duct services:

1. Indoor, concealed supply and outdoor air.

2. Indoor, exposed supply and outdoor air.

1.03 SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied if any).

B. Qualification Data: For qualified Installer.

1.04 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, 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.

2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by Manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.06 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."

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

C. Coordinate installation and testing of heat tracing.

1.07 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

2.01 INSULATION MATERIALS

A. Comply with requirements in "Duct Insulation Schedule, General," "Indoor Duct and Plenum Insulation Schedule," and "Aboveground, Outdoor Duct and Plenum 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 in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

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

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. CertainTeed Corp.; SoftTouch Duct Wrap.

    b. Johns Manville; Microlite.

c. Knauf Insulation; Friendly Feel Duct Wrap.

d. Manson Insulation Inc.; Alley Wrap.

e. Owens Corning; SOFTR All-Service Duct Wrap.

F. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

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. CertainTeed Corp.; Commercial Board.

b. Fibrex Insulations Inc.; FBX.

c. Johns Manville; 800 Series Spin-Glas.

d. Knauf Insulation; Insulation Board.

e. Manson Insulation Inc.; AK Board.

f. Owens Corning; Fiberglas 700 Series.

2.02 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.

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. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.

b. Eagle Bridges - Marathon Industries; 225.

c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.

d. Mon-Eco Industries, Inc.; 22-25.

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

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. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.

    b. Eagle Bridges - Marathon Industries; 225.

    c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-50.

    d. Mon-Eco Industries, Inc.; 22-25.

2.03 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

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

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. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80/30-90.

    b. Vimasco Corporation; 749.

2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.

3. Service Temperature Range: Minus 20 to plus 180 deg F.

4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.

5. Color: White.

2.04 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:

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. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.

b. Eagle Bridges - Marathon Industries; 405.

c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 95-44.

d. Mon-Eco Industries, Inc.; 44-05.

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

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

4. Service Temperature Range: Minus 40 to plus 250 deg F.

5. Color: Aluminum.

2.05 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 C 1136, Type II.

2.06 TAPES

A. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

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. ABI, Ideal Tape Division; 491 AWF FSK.

b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.

c. Compac Corporation; 110 and 111.

d. Venture Tape; 1525 CW NT, 1528 CW, and 1528 CW/SQ.

2. Width: 3 inches.

3. Thickness: 6.5 mils.

4. Adhesion: 90 ounces force/inch in width.

5. Elongation: 2 percent.

6. Tensile Strength: 40 lbf/inch in width.

7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

2.07 SECUREMENTS

A. Insulation Pins and Hangers:

1. 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.

   a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

      1) AGM Industries, Inc.; CWP-1.

      2) GEMCO; CD.

      3) Midwest Fasteners, Inc.; CD.

      4) Nelson Stud Welding; TPA, TPC, and TPS.

2. 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.

   a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

      1) AGM Industries, Inc.; CHP-1.

      2) GEMCO; Cupped Head Weld Pin.

      3) Midwest Fasteners, Inc.; Cupped Head.

      4) Nelson Stud Welding; CHP.

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

   a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

      1) AGM Industries, Inc.; RC-150.

2) GEMCO; R-150.

3) Midwest Fasteners, Inc.; WA-150.

4) Nelson Stud Welding; Speed Clips.

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

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

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) GEMCO.

2) Midwest Fasteners, Inc.

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

PART 3 – EXECUTION

3.01 EXAMINATION

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

1. Verify that systems to be insulated have been tested and are free of defects.

2. Verify that surfaces to be insulated are clean and dry.

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

3.02 PREPARATION

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

3.03 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. For any ductwork that has insulation, apply vapor-barrier mastic over staples and follow manufacturer recommended installation instructions.

G. Keep insulation materials dry during application and finishing.

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 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.

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. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.

4. For any ductwork that has insulation, apply vapor-barrier mastic over staples and follow manufacturer recommended installation instructions.

5. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.

6. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than 75 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 similar to butt joints.

3.04 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.

B. Board 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, space 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. 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. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

6. 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.

3.05 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:

1. Indoor, concealed supply, return and outdoor air.

2. Indoor, exposed supply, return and outdoor air.

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. Factory-insulated access panels and doors.

3.06 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Concealed, Rectangular, supply-air duct insulation shall be the following:

1. Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.

B. Exposed, Rectangular, supply-air duct insulation shall be the following:

1. Mineral-Fiber Board: 1-1/2 inches thick and 1.50-lb/cu. ft. nominal density.

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SECTION 15095

VALVES, GENERAL

PART 1 – GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish and install, complete with all assemblies and accessories, all valves shown on the Drawings and specified herein including all fittings, appurtenances and transition pieces required for a complete and operable installation.

B. All valves shall be constructed of first quality materials which have strength, wearing, and corrosion resistance characteristics entirely suitable for the types of service for which the individual valves are designated. Except where noted otherwise, valves designated for water service shall conform to pertinent sections of the latest revision of AWWA C500 Specifications. Cast iron valve bodies and parts shall meet the requirements of the latest revision of ASTM Designation A-126, "Standard Specifications for Gray Iron Castings for Valves, Flanges, and Pipe Fittings, Class B."

C. All valve body castings shall be clean, sound, and without defects of any kind. No plugging, welding, or repairing of defects will be allowed.

D. Valves shall have flanged ends for exposed service and mechanical joint ends for buried service, unless otherwise shown on the Drawings or specified herein. Flanged ends shall be flat-faced, 125 lb. American Standard unless otherwise shown or specified in accordance with ANSI B16.1. All bolt heads and nuts shall be hexagonal of American Standard size. The Contractor shall be responsible for coordinating connecting piping. Valves with screwed ends shall be made tight with Teflon tape. Unions are required at all screwed joint valves.

1.02 SUBMITTALS

A. The following items shall be submitted in accordance with, or in addition to the submittal requirements specified in Section 01300 – Submittals and Section 11000 – Equipment General Provisions:

1. Performance tests shall be conducted in accordance with the latest revision of AWWA C500.

2. Shop Drawings conforming to the requirements of Section 01300 – Submittals, are required for all valves, and accessories. Submittals shall include all layout dimensions, size and materials of construction for all components, information on support and anchoring where necessary, pneumatic and hydraulic characteristics and complete descriptive information to demonstrate full compliance with the Documents. Shop Drawings for electrically operated/controlled valves shall include

all details, notes, and diagrams which clearly identify required coordination with the electrical power supply and remote status and alarm indicating devices. Electrical control schematic diagrams shall be submitted with the Shop Drawings for all electrical controls. Diagrams shall be drawn using a ladder-type format in accordance with JIC standards. Shop Drawings for pneumatically operated/controlled valves shall include all details, notes, and diagrams which clearly identify required coordination with the compressed air (service air) system and electrical controls.

3. Operation and maintenance manuals and installation instructions shall be submitted for all valves and accessories in accordance with the Specifications. The manufacturer(s) shall delete all information which does not apply to the equipment being furnished.

1.03 CONTRACTOR'S RESPONSIBILITIES

A. The Contractor shall provide the services of a qualified representative of the manufacturer(s) of the equipment named below to check out and certify the installation(s), to supervise the initial operation, and to instruct the Owner's operating personnel in proper operation and maintenance procedures in accordance with the following schedule:

Item	Valve/Operator Type	Minimum On-Site Time Requirements
1	Actuated Plug Valve	One (1) 8-hour day
2	Motor operated open-close valves (other than 2)	One (1) 8-hour day

B. Any additional time required to achieve successful installation and operation shall be at the expense of the Contractor. The manufacturer's representative shall sign in and out at the office of the Engineer's Resident Project Representative on each day they are at the project.

C. A written report covering the representative's findings and installation approval shall be mailed directly to the Engineer covering all inspection and outlining in detail any deficiencies notes.

D. The times specified are exclusive of travel time to and from the facility and shall not be construed as to relieve the manufacturer of any additional visits to provide sufficient service to place the equipment in satisfactory operation.

PART 2 – PRODUCTS

2.01 VALVE BOXES

A. The Contractor shall furnish and install valve boxes as shown on the Drawings and specified herein.

B. All valve boxes shall be placed so as not to transmit shock or stress to the valve and shall be centered and plumb over the operating nut of the valve. The ground in the trench upon which the valve boxes rest shall be thoroughly compacted to prevent settlement. The boxes shall be fitted together securely and set so that the cover is flush with the finished grade of the adjacent surface. A concrete pad as detailed on the Drawings shall be provided around the valve box, sloped outwards.

C. Valve boxes shall be adjustable, cast iron and suitably sized to the valve with a minimum diameter of 5 inches. The cover shall have the word “SEWER”: legibly cast into the face. Boxes shall be suitable for H-20 loading and equal to Clow, M and H, or U. S. Foundry. Valve boxes shall be labeled to identify type of valve, depth and number of turns required on a brass marker permanently affixed to the valve box cover.

2.02 BACKFLOW PREVENTERS

A. Backflow preventer shall be the size shown on the Drawings and shall be of the double check valve principle. Backflow preventer installation shall include isolation valves and four test cocks, furnished as an assembly. For backflow preventers less than 2-1/2", the installation assembly also shall include a strainer. Isolation valves for backflow preventers shall be ball valves, except for size 2-1/2" and larger which shall be resilient seat gate valves. Test cocks shall be located as recommended by the manufacturer to facilitate functional testing of the assembly. The backflow preventer shall be a WATTS 709, or equal.

B. Reduced Pressure Backflow Preventer shall be of the size shown on the Drawings and shall be of the reduced pressure principle type in accordance with AWWA Standards C510 and C511, with two (2) independent operating spring loaded check valves and one (1) spring loaded, diaphragm actuated, differential pressure relief valve shall be installed between the check valves. Backflow preventer shall be bronze body construction, with EPT rubber discs and Buna-N and nylon diaphragm. Screws and springs shall be of stainless steel. End connections shall be screwed, unless otherwise specified or shown on the Drawings. Reduced pressure backflow preventer installations shall include isolation valves and four test cocks, furnished as an assembly. For reduced pressure backflow preventers less than 2-1/2" the installation assembly also shall include a strainer. Isolation valves for reduced pressure backflow preventers shall be ball valves, except for sizes 2-1/2" and larger which shall be resilient seat gate valves. Test cocks shall be located as recommended by the manufacturer to facilitate functional testing of the assembly. The reduced pressure backflow preventer shall be as manufactured by Beeco Division, Hersey Products Inc., Aergap Model 6CM, WATTS 909, or equal.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Except where noted otherwise herein, all valves shall be installing and tested in accordance with the latest revision of AWWA C500. Before installation, all valves shall be

lubricated, manually opened and closed to check their operation and the interior of the valves shall be thoroughly cleaned. Nuts and bolts shall be inspected for tightness. Special care shall be taken to prevent joint materials, stones and other substances from becoming lodged in the valve seat. Any valve that does not operate correctly shall be replaced. Valves shall be placed in the positions shown on the Drawings. Joints shall be made as directed under the Piping Specifications. The valves shall be so located that they are easily accessible for operating purposes and shall bear no stresses due to loads from the adjacent pipe. The Contractor shall be responsible for coordinating connecting piping.

B. All valves shall be tested at the operating pressures at which the particular line will be used. Any leakage or "sweating" of joints shall be stopped, and all joints shall be tight. All motor operated and cylinder operated valves shall be tested for control operation as directed by the Engineer.

C. Provide valves in quantity, size, and type with all required accessories as shown on the Drawings.

D. Install all valves and appurtenances in accordance with manufacturer's instructions. Install suitable corporation stops at all points shown or required where air binding of pipe lines might occur. Install all valves so that operating handwheels or wrenches may be conveniently turned from operating floor but without interfering with access, and as approved by Engineer. Unless otherwise approved, install all valves plumb and level. Valves shall be installed free from distortion and strain caused by misaligned piping, equipment or other causes.

E. Valve boxes shall be set plumb and centered with the bodies directly over the valves so that traffic loads are not transmitted to the valve. Earth fill shall be carefully tamped around each valve box to a distance of 4 feet on all sides of the box, or to the undisturbed trench face, if less than 4 feet.

F. All valve boxes shall be centered over the operating nut of underground valves to permit a valve wrench to be easily fitted to the nut. Top of boxes shall be set to final grade. The valve box shall not transmit surface loads directly to either the pipe or valve. Care shall be used to prevent earth and other materials from entering the boxes. Any valve box that becomes out of alignment or is not to grade shall be dug out and adjusted. A concrete collar which identifies the valve shall be provided

3.02 SHOP AND FIELD TESTING

A. Shop and field testing of valves shall be as follows:

1. Certified factory testing shall be provided for all components of the valve and operator system. Valves and operators shall be shop tested in accordance with the requirements in the latest revision of AWWA C500, including performance tests, leakage test, hydrostatic tests, and proof-of-design tests. The manufacturer through the Contractor shall submit certified copies of the reports covering the test for acceptance by the Engineer.

2. Shop testing shall be provided for the operators consisting of a complete functional check of each unit. Any deficiencies found in shop testing shall be corrected prior to shipment. The system supplier through the Contractor shall submit written certification that shop tests for the electrical/pneumatic system and all controls were successfully conducted and that these components provide the functions specified and required for proper operation of the valve operator system.

3. The Contractor shall conduct field tests to check and adjust system components, and to test and adjust operation of the overall system. Preliminary field tests shall be conducted prior to start-up with final field tests conducted during start-up. The factory service representative shall assist the Contractor during all field testing and prepare a written report describing test methods, and changes made during the testing, and summarizing test results. The service representative shall certify proper operation of the valve operator system upon successful completion of the final acceptance field testing.

4. Preliminary and final field tests shall be conducted at a time approved by the Engineer. The Engineer shall witness all field testing.

5. All costs in connection with field testing of equipment such as energy, light, lubricants, water, instruments, labor, equipment, temporary facilities for test purposes, etc. shall be borne by the Contractor. The Contractor shall be fully responsible for the proper operation of equipment during tests and instruction periods and shall neither have nor make any claim for damage which may occur to equipment prior to the time when the Owner formally takes over the operation thereof.

6. Preliminary field tests shall be conducted prior to start-up and shall include a functional check of the entire valve operator system and all system components. Preliminary field tests shall demonstrate that the valve operator system performs according to specifications and that all equipment, valves, controls, alarms, interlocks, etc., function properly. The preliminary field test report must be approved by the Engineer prior to conducting final field acceptance tests. Based on results of preliminary field tests, the Contractor shall make any adjustments required to settings, etc., to achieve the required valve closing time and operation specified or otherwise directed by the Engineer.

7. Final field acceptance tests shall be conducted simultaneously with the start-up and field testing of the pumps, etc. Field tests shall be conducted for the full range of operating modes and conditions specified and as directed by the Engineer. Each of the valves shall be tested at minimum, maximum, and normal head/flow conditions, and under all specified conditions of opening and closing.

8. Field testing shall include optimization of opening and closing times of the valves. The Contractor shall provide the means for accurate measurement of pipeline pressures as directed by the Engineer. Valve opening and closing times shall be adjusted based on process requirements to optimize operation of the valves. Final valve opening and closing times as determined by field tests shall be approved by the Engineer prior to final acceptance of the system.

- END OF SECTION -

SECTION 15100

VALVE OPERATORS AND ELECTRIC ACTUATORS

PART 1 – GENERAL

1.01 THE REQUIREMENT

A. Equipment shall be provided in accordance with the requirements of Section 11000 – Equipment General Provisions and Section 15000 – Basic Mechanical Requirements.

B. Reference Section 15390 –Pipe Schedules for additional information on valves and operators.

C. Valve operators and electric valve actuators shall be designed to unseat, open or close, and seat the valve under the most adverse operating condition to which the valves will be subjected.

D. The electric valve actuators shall meet the signal and process control requirements as included in Divisions 13 and 16.

E. Operator mounting arrangements shall be as indicated on the Drawings or as directed by the manufacturer and/or Engineer.

F. The valve operators and electric actuators shall be the full and undivided responsibility of the valve manufacturer in order to ensure complete coordination of the components and to provide unit responsibility.

1.02 SUBMITTALS

A. The following items shall be submitted in accordance with, or in addition to the submittal requirements specified in Section 01300 – Submittals and Section 11000 – Equipment General Provisions:

1. Shop Drawings

2. O&M Manuals

3. Certification that the force required to operate all valves is as specified herein.

PART 2 – PRODUCTS

2.01 GENERAL

A. Electric actuators shall be provided where specified in the Valve Schedule in Section 15390 –Pipe Schedules.

B. Manual operators shall be provided on all valves which do not receive electric actuators. Manual operator type shall be as specified herein and as shown on the Drawings.

C. Quarter turn valves 6” and greater in size shall have geared operators. Gate valves 14” and greater in size shall have geared operators.

D. Operators shall be furnished with conservatively sized extension bonnets, extension stems, or torque tubes, and all required appurtenances required for a complete installation. Operators furnished with extension bonnets shall include stainless steel extension stems, or stainless-steel torque tubes.

2.02 MANUAL OPERATORS

A. Unless otherwise specified or shown on the Drawings, manual operator type shall be as follows:

1. Buried valves shall be equipped with nut operators, extended stems, and valve boxes. Where the depth of the operating nut is more than 4 feet below finish grade, a valve operator extension shall be provided to bring the operating nut to within 18-24 inches of the surface.

2. Exposed valves up to 4-inch shall be lever operated (except gate valves).

3. Exposed valves 4-inches and larger shall be handwheel operated.

4. Exposed gate valves shall be handwheel operated.

5. Valves with centerline of operator located more than 6-feet above the floor or platform from which it is to be operated shall have a chainwheel operator unless otherwise indicated on the Drawings.

B. Manual operators shall be rigidly attached to the valve body unless otherwise specified or shown on the Drawings.

C. All operators shall turn counter-clockwise to open and shall have the open direction clearly and permanently marked.

D. Valve operators shall be designed so that the force required to operate the handwheel, lever, or chain (including breakaway torque requirements) does not exceed 80 pounds applied at the extremity of handwheel or chainwheel operator. Design pressures for sizing of valve operators shall be the piping test pressure for the piping in which the valve is to be installed as shown in the Piping Schedule in Section 15390 – Pipe Schedules.

E. Handwheels for valves operators shall not be less than 12 inches in diameter. The maximum diameter of any handwheel shall not exceed 24”.

F. Nut operators shall have standard 2-inch square AWWA operating nuts designed in accordance with AWWA C504-94.

G. Geared manual operators shall be of the worm gear, traveling nut or scotch yolk type except manual operators for butterfly valves 18-inch in diameter or larger which shall be worm gear, unless otherwise indicated in the individual valve specification. Gear operators shall be of the worm gear or bevel gear type. Gear box designs incorporating end of travel stops in the housing shall be equipped with AWWA input stops. Each gearbox shall require a minimum of 10 turns for 90-degree rotation or full valve stem travel and shall be equipped with a mechanical valve position indicator.

H. Manual operators on below grade (and vault installed) valves shall be permanently lubricated and watertight under an external water pressure of 10 psi.

2.03 ELECTRIC VALVE ACTUATORS

A. Electric Actuators shall be open/close service or modulating service as specified in the Schedule in Section 15390 –Pipe Schedules.

1. Open/Close (non-modulating) valve actuators shall be IQ series as manufactured by Rotork, SA series as manufactured by AUMA, or Series 2000 as manufactured by Bettis.

2. Modulating valve actuators shall be Type IQM as manufactured by Rotork, Type SAR as manufactured by AUMA, or Series 2000 Futronic as manufactured by Bettis.

B. Performance Requirements

1. The actuators shall be designed for indoor and outdoor service and shall be capable of mounting in any position.

2. Torque capacity of the actuators shall be sufficient to operate the valves with the maximum pressure differential, as indicated in the Valve Schedule in Section 15390 – Pipe Schedules, with a safety factor of 1.5. Actuators in modulating service will be selected such that the required dynamic valve torque is no more than 60% of the electric actuator’s maximum rated breakaway of torque.

3. Operating time for full limits of travel shall be not more than 2 seconds per inch diameter of the valve, +/- 50 percent through 20 inches; +/- 30 percent for valves 24 inches and larger. Operating time shall not be less than 60 seconds for all modulating valves.

4. Actuators shall be capable of operating in ambient temperatures ranging from 0 degrees F – 160 degrees F.

5. For open/close (non-modulating) actuators, the gearing, motor and contactor shall be capable of 60 starts per hour without overheating.

6. For modulating actuators, the gearing, motor and contactor shall be capable of 1200 starts per hour without overheating.

C. The actuators shall include, in one integral housing, individual compartments for the motor, gearing, wiring terminals, and control circuits. The terminal compartment shall be separated from the inner electrical components of the actuator by means of a watertight seal. The inner seal shall protect the motor and all other internal electrical elements of the actuator from entrance of moisture and dust when the terminal cover is removed. Double cartridge shaft seals shall be provided on the hand wheel and output shafts for weatherproof protection. All external fasteners shall be stainless steel. Compartments shall be provided with moisture and dust-proof rigid cast covers meeting NEMA 6, certified to submergence in 6 ft of water for 30 minutes. Actuators located in classified areas shall be suitable for use in Class 1, Division 1, Group D environments.

D. The actuators shall be provided with externally operable and lockable 480VAC circuit breakers integral to the control housing

E. All gearing shall be hardened alloy steel or bronze and shall be rated at twice the output torque of the operator and shall be designed to withstand the stall torque of the motor without failure. Output drive gearing shall consist of a worm shaft and worm gear pinion operating in an oil bath. The worm gear pinion shall be alloy bronze. Worm gear drive shall be self-locking to prevent creeping of the valve disc in an intermediate position. Heavy-duty grease shall protect gearing and sealed ball bearings of the main shaft for five years without changing. Motor reduction gearing shall be spur or planetary gearing and shall allow for field repair and change in gear ratio. For quarter turn applications, overtravel of the operator shall be prevented by internal mechanical stops cast into the actuator.

F. A mechanical dial position indicator shall be furnished to continuously indicate the position of the valve at and between the fully open and fully closed positions. The indicator shall be driven by gearing driven off of the main worm gear pinion and shall operate when the actuator is in either the electrical mode or manual mode.

G. A handwheel shall be permanently attached for manual operation. A gear assembly shall be provided between the handwheel and the worm shaft if required to reduce the force necessary to operate the handwheel to less than 40 pounds. A positive declutch mechanism shall engage the handwheel when required. When the actuator is set in the declutched position for handwheel operation, it shall return automatically to electric operation when actuator motor is energized. The handwheel shall not rotate during electric operation nor shall a fused motor prevent handwheel operation.

H. The drive motor shall be specifically designed for actuator service and shall be characterized by high starting torque and low inertia. Motors shall be 460 volts, three phase, 60 Hz AC reversible squirrel cage induction type motors and shall be specifically designed for modulating service where indicated on the Valve Schedule in Section 15390 – Pipe Schedules. Motors shall be totally enclosed, non-ventilated, with NEMA Class F insulation minimum (Class H for modulating actuators) and a maximum continuous temperature rating of 120 degree C (rise plus ambient). A space heater shall be provided in the motor compartment. The electric motor shall have a time rating of at least 15 minutes at 104°F (40°C) or twice the valve stroking time, whichever is longer, at an average load of at least 33% of maximum valve torque. Motor bearings shall be permanently lubricated

by premium lubricant. The motor shall have plug and socket electrical connection to facilitate easy removal and replacement. The actuator shall include a device to ensure that the motor runs with the correct rotation for the required direction of valve travel with either phase sequence of the three-phase power supply connected to the actuator. The motor shall include single phase protection. A suitable thermal protection device shall be incorporated in the motor or motor starter circuits, connected to a tripping device. Fast acting fuses shall be provided to protect solid state components. The motor shall be capable of starting against the rated load in either the open or close direction when voltage to the motor terminals is plus or minus ten (10) percent of nameplate rating.

1. Open/Close actuators shall be furnished with electro-mechanical reversing starters.

2. Modulating actuators shall be furnished with solid state reversing starters utilizing thyristors.

I. Leads from the motor shall be brought to the control circuit (limit switch) compartment without external piping or conduit box. An adequately sized space heater shall be installed in the control circuit compartment to aid in the prevention of damage resulting from condensation. The following items shall be located in the control circuit compartment.

1. Torque limit switches shall be provided to de-energize the motor control circuit in the event of a stall when attempting to unseat a jammed valve and when torque is exceeded during valve travel. Each actuator shall have an open direction torque switch and a close direction torque switch. The torque switches shall be mechanically operated and able to be set in torque units. Torque switches shall be calibrated prior to the actuator's assembly to the valve.

2. Travel limit switches shall be provided to de-energize the motor control circuit when the actuator reaches the limits of travel in the open and close directions. The limit switch drive shall be of the counter gear type and "in step'" with the actuator output drive at all times in either the electrical or manual mode of operation. A minimum of six (6) contacts, three (3) normally open and three (3) normally closed, shall be supplied at each end of valve travel. Four (4) additional contacts shall be provided to report end of travel or any desired position between ends of travel.

J. Modulating actuators shall have a position feedback potentiometer mounted directly to the valve actuator gearing inside the gearing compartment. The potentiometer shall provide a 4-20 mA signal corresponding to valve position. Modulating valve actuators shall be designed to respond to either a 4-20mADC analog signal or a digital pulse signal as specified herein or as required to coordinate with the requirements of Division 13, 15 and 16.

1. Modulating valve actuators designed to respond to a 4-20mADC signal shall be provided with a valve positioner which shall position the valve proportional to an externally generated 4-20mADC signal. The valve positioning control circuitry shall position the valve by comparing the command signal with the present valve position as indicated by the feedback potentiometer. The positioner shall be field adjustable

to fail to the “open,” “closed,” or “last” position on loss of 4-20 mADC command signal.

2. Modulating valve actuators designed to respond to “pulse” open/close signals shall operate the valve during the time the open or close pulse signal is high. Modulating actuators designed to respond to “pulse” open/close signals shall have the latching circuitry described above for open/close actuators disabled.

K. The electrical terminals shall be housed in a double sealed terminal compartment isolated from the rest of the actuator components. The actuators shall be designed to operate from a single 480VAC, 3-phase source. The actuators shall be furnished with fuses inside of the terminal compartment. A quantity of two – ¾ inch NPT conduit entries shall be furnished.

L. Actuators shall contain wiring and terminals for the following control functions. All dry contacts shall be rated for 5A at 250VAC.

1. Open, Close, and Stop commands from external dry contacts (utilizing internal 24VDC [120VAC] power supply) and/or from an external signal of 12V to 120V. The inputs for the open, close, stop signals shall be field selectable to be respond to either maintained or momentary remote signals. In momentary mode, the actuator shall have internal latching circuitry that causes the operator to drive the valve to its limit of travel upon receipt of the momentary contact signal unless a stop signal is received.

2. Emergency override input from a normally closed or normally open contact. The actuator shall either open or close (field selectable) upon receiving the emergency override input.

3. Remote Local-Off-Remote selector switch, Open/Close pushbuttons, and Open/Closed pilot lights for a remote manual control station (see below). The remote Local-Off-Remote selector switch and Open/Close pushbuttons shall be a dry contact input to the actuator control circuitry. The Open/Closed pilot lights shall be powered from the valve actuator control power.

4. Four (4) unpowered contacts shall be provided which can be selected to indicate valve “Opened” and “Closed” position, “Remote” status of the actuator, and fail status of the actuator. The fail status contacts shall activate upon motor overtemperature and actuator overtorque as a minimum.

5. Terminals for 4-20mADC position command and 4-20mADC position feedback as described above for modulating actuators.

M. Local Controls

1. Actuators shall be furnished with a Local-Off-Remote selector switch; Open, Close, and Stop pushbuttons for local control; a red lamp indicating closed and a green

lamp indicating open. L-O-R switch shall be padlockable in any of the three positions.

a. When the LOR is in the “Local” position, open/close control shall be by the open and close pushbuttons on the actuator. The stop push button shall stop the actuator travel.

b. When the LOR is in the “Off” position, the actuator shall not operate.

c. When the LOR is in the “Remote” position, the actuator shall be controlled by remote inputs from the PLC or from the remote manual controls station.

2. The local controls shall be arranged so that the direction of travel can be reversed without the necessity of stopping the actuator.

N. Remote Manual Control Station

1. Where indicated in the Valve Schedule in Section 15390 – Pipe Schedules, manual actuator controls shall be furnished in a separate NEMA 4X stainless steel enclosure (NEMA 7 if located in a classified area). Manual control station controls shall include Hand–Off-Auto Selector switch; Open, Stop, and Close pushbuttons; a red lamp indicating closed and a green lamp indicating open.

a. When the HOA is in the “Hand” position, open/close control shall be by the open and close pushbuttons on the remote manual control station. The stop push button shall stop actuator travel.

b. When the HOA is in the “Off” position, the actuator shall not operate.

c. When the HOA is in the “Auto” position, the actuator shall be controlled by remote inputs to the valve actuator from the PL

O. Operators shall be furnished with communication cards to allow direct digital control of the electric actuator position and to receive actuator position over the network. Communication protocol shall be MODBUS per the latest MODICON standard. Two MODBUS modules shall be provided in each actuator to allow fully redundant communications capability. If one module fails the system shall automatically backup to the other module. The modules shall be allowed to simultaneously communicate on two separate MODBUS networks. The following I/O shall be made available in the actuator registers for read/write access by the PLC [DCS]:

1. Valve position (0-100%)

2. Valve position command (0-100%)

3. OPEN Command

4. CLOSE Command

5. STOP Command

6. Actuator pulse (Allows valve time of travel to be increased/reduced)

7. REMOTE selected (Indicates L-O-R switch is in the REMOTE position)

8. LOCAL selected

9. OPEN position indication (Valve is in open position)

10. CLOSE position indication

11. Center column moving

PART 3 – EXECUTION

3.01 MANUFACTURER'S FIELD SERVICES

A. The services of a qualified manufacturer's technical representative shall be provided in accordance with Section 11000 – Equipment General Provisions and shall include the following site visits for electric actuators as a minimum to complete all work:

Service	Number of Trips	Number of Days/Trip
Installation and Testing	1	1
Startup and Training	1	1
Services after Startup	1	1

3.02 INSTALLATION

A. All valve actuators shall be installed in accordance with the manufacturer's published recommendations and the applicable Specification Sections for valves and motor controls.

B. Valve actuators shall be factory coated in accordance with the manufacturer's standard paint system.

3.03 SHOP TESTING

A. Shop testing shall be in accordance with Section 11000 – Equipment General Provisions and with the following additional requirements:

1. Conduct a complete functional check of each unit. Correct any deficiencies found in shop testing prior to shipment.

2. Submit written certification that:

a. Shop tests for the electrical system and all controls were successfully conducted.

b. Electrical system and all controls provide the functions specified and required for proper operation of the valve operator system.

3. Each actuator shall be performance tested and individual test certificates shall be supplied free of charge. The test equipment shall simulate each typical valve load and the following parameters should be recorded:

a. In addition, the test certificate should record details of specification, such as gear ratios for both manual and automatic drive and closing direction.

b. Verification of actuator torque rating with valve.

3.04 FIELD TESTS

A. Field testing shall be in accordance with Section 11000 – Equipment General Provisions and with the following additional requirements:

1. Valve actuators shall be field-tested together with the associated valves.

2. Test all valves at the operating pressures at which the particular line will be used.

3. Test all valves for control operation as directed.

4. Field testing shall include optimization of opening and closing times of the valves. Valve opening and closing times shall be adjusted based on process requirements to optimize operation of the valves. Final valve opening and closing times as determined by field tests shall be approved by the Engineer prior to final acceptance of the system.

B. Preliminary Field Tests

1. General: Preliminary field tests shall be conducted prior to start-up and shall include a functional check of the entire valve operator system and all system components.

2. Scope: Preliminary field tests shall demonstrate that the valve operator system performs according to specifications and that all equipment, valves, controls, alarms, interlocks, etc., function properly.

3. Based on results of preliminary field tests, the Contractor shall make any adjustments required to settings, etc., to achieve the required valve closing time and operation, as specified or otherwise directed.

C. Final Field Tests

1. Final field tests shall be conducted in accordance with the latest revision of AWWA C500.

2. Final field tests shall be conducted simultaneously with the start-up and field testing of the pumps.

3. Final field tests shall be conducted for the full range of operating modes and conditions specified and as directed by the Engineer. Each of the valves shall be tested at minimum, maximum, and normal head/flow conditions, and under all specified conditions of opening and closing.

4. Certification of Equipment Compliance: After the final field tests are completed and passed, submit affidavit according to Section 11000 – Equipment and General Provisions.

- END OF SECTION -

SECTION 15105

CHECK VALVES

PART 1 – GENERAL

1.01 THE REQUIREMENT

A. Reference Section 15000 – Basic Mechanical Requirements.

PART 2 – PRODUCTS

2.01 SWING CHECK VALVES

A. Check valves shall have ductile iron body, flanged ends, bronze-mounted, stainless steel hinge pin, replaceable rubber faced clapper, outside spring or lever operated, equipped with weight actuator, swing non-slam type and equipped with removable inspection covers.

B. Check valves shall be rated for 150 psi minimum working pressure and permit full flow area equal to that of the connecting pipe.

C. Valves shall be manufactured by Mueller and be equipped with a lever and spring assembly.

D. Valve closure shall be controlled by an external spring lever arm.

E. Valve bodies, cover discs, levers, and disc arms shall be constructed of heavy cast iron or cast steel fully conforming to the latest revision of ASTM A-126 Class B or Class WCB, respectively. Valve ends shall be Standard American 125 pound flat-faced flanged, in accordance with ANSI B16.1. Each valve disc shall be suspended from a noncorrosive shaft which shall pass through a stuffing box and be connected on the outside of the valve to the cushion and counterweight mechanism.

F. Valve seating shall be rubber-to-metal designed for drop-tight shutoff. The body seat ring shall be made of bronze or stainless steel and the disc seat ring of 80 Durometer rubber. Body and disc seats shall be renewable.

G. With the exception of the valve body and seat, all parts in contact with water shall be manufactured from noncorrosive materials. Internal corrosive surfaces shall be shop painted with two coats of epoxy for corrosion resistance. Exterior surfaces shall be painted in accordance with the requirements of Section 09 90 00 – Painting.

PART 3 – EXECUTION (NOT USED)

- END OF SECTION -

SECTION 15109

PLUG VALVES

PART 1 – GENERAL

1.01 THE REQUIREMENT

A. Reference Section 15000 – Basic Mechanical Requirements.

1.02 SUBMITTALS

A. As required in Section 15095 – Valves, General, and Section 01300 – Submittals.

B. The Contractor shall furnish to the Owner, through the Engineer, a Performance Affidavit, utilizing the format specified in Section 11000 – Equipment General Provisions.

C. Performance tests shall be conducted in accordance with the latest revision of AWWA C517 and affidavits shall conform to the requirements of the Specifications.

PART 2 – PRODUCTS

2.01 ECCENTRIC PLUG VALVES

A. GENERAL

1. Plug valves shall have a semi-steel body, non-lubricated, eccentric type, 100% port opening, with resilient faced plugs capable of drip-tight bi-directional shut-off at the full rated pressure.

2. Valves and appurtenances shall be as manufactured by DeZurik or Val-Matic. Valves shall be equipped with Limitorque or Rotork 460/3/60 electric actuators.

3. Valves shall be lined with a factory applied ceramic epoxy material such as SP2000 Protecto 401, or an approved equal.

4. All valves shall be provided with limit stops and rotate 90º from fully-open to fully-shut.

5. The minimum working pressure shall be 175 psi for valves 12-in and smaller and 150 psi for valves 14-in and larger. Seat shall be hydrostatically tested to the valve design working pressure. Shell hydrostatic test pressure, with plug open and valve ends sealed, shall be 150 percent of the valve rated working pressure in accordance with AWWA C517.

6. Valve body shall be epoxy coated ductile iron, cast iron or semi-steel, unless specified otherwise, and coated as specified herein.

7. Seats shall have a welded overlay of one-half inch wide 90 percent pure nickel and machined to a finish containing no stress cracks. Minimum overlay thickness shall be one-eighth inch. The plug shall contact only the raised nickel seat surface.

8. Plug facings shall be of Nitrile Butadiene and completely suitable for use with domestic sewage.

9. The shaft seal shall be V-Type with minimum four sealing rings and a follower ring. Stuffing box shall be designed with a space between the bonnet and actuator so that packing can be inspected, adjusted, and replaced without removing the valve actuator.

10. Bearings shall be sleeve type with the following materials.

    a. Sizes 4 – 18 inch: Sintered, oil impregnated, permanently lubricated type 316 stainless steel.

11. Provide PTFE ring on the shaft between plug and body to serve as a thrust bearing and grit excluder.

12. All buried valves shall have mechanical joint ends (unless otherwise shown), conforming to ANSI A21.11 (AWWA C 111). Buried valves shall have mechanical joint connections. Buried valves shall have stem extensions which shall bring the operating nut within two feet of finished grade. Stem extension shall be contained within an appropriately sized valve box. Gear actuators for valves 8 inches or larger shall be provided.

13. Unless otherwise shown, all exposed valves 4-inches in diameter and larger shall have flanged ends conforming to ANSI B16.1-125/150-pound standard with face-to-face dimensions of standard plug valves. Valves smaller than 4-inches in diameter shall have screwed ends, unless otherwise noted.

14. Valves 8-inches in diameter and larger shall be handwheel or floorstand-operated where required or indicated on the Drawings through totally enclosed worm gear actuators, unless otherwise specified or shown on the Drawings. Valves 6-inches in diameter and smaller shall have lever operators, unless otherwise specified or noted on the Drawings. Manual operators for plug valves mounted above 6 feet from the operating floor shall be equipped with worm gear chainwheel actuators.

15. The manufacturer shall certify that the plug valves are capable of operating in continuous duty service under the specified pressures and flow conditions.

16. Each valve shall be hydrostatically tested and tested for bubble tightness after the operator has been mounted and adjusted. Copies of the hydrostatic and leakage

test certification and certification of conformance shall be submitted to the Engineer prior to shipment.

17. All internal and external ferrous components and surfaces of the valves, with the exception of stainless steel and finished or bearing surfaces, shall be shop painted with two coats (10 mils min. dry film thickness) of the manufacturer's premium epoxy for corrosion resistance. Damaged surfaces shall be repaired in accordance with the manufacturer's recommendations.

PART 3 – INSTALLATION

A. Install in accordance with the manufacturer’s recommendations.

B. In applications with suspended solids in the liquid or for dirty gases:

1. Vertical pipelines: Install valve with the seat end at the top.

2. Horizontal pipelines: Install valve so plug rotates upwards when opening. Higher pressure side of the valve, when closed, shall be on the valve end opposite of the seat.

C. In applications with clean liquids or gases install the valve with the higher-pressure side of the valve, when closed, on the opposite end of the valve from the seat.

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SECTION 15187

REFRIGERANT PIPING

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 WORK INCLUDED

A. Refrigerant (RS/RL/RHG) Piping.

B. Valves and Specialties

1.03 DEFINITIONS

A. The pipe sizes given in this document shall be construed as nominal pipe sizes.

1.04 QUALITY ASSURANCE

A. All material provided under this section shall be standard catalogued products of recognized manufacturers regularly engaged in the production of such products and shall be of the manufacturer's most recent design that is in regular production.

B. Each item provided under this section shall meet the requirements for that item as installed and used, in accordance with the following standards:

1. Metallic Piping Systems employing mechanical joints and grooved-end pipe - ASME/ANSI B-31.9

2. Refrigeration Piping and Heat Transfer Components - ASME/ANSI B31.5

3. Safety Code for Refrigeration Systems – ASHRAE 15

4. Refrigerant Containing Components and Accessories – UL 207

C. Each piping system shall be in accordance with the system design pressures shown in paragraph 2.1 -Materials, this specification section.

D. All materials provided under this section shall be new, except where the specifications and/or drawings permit the reuse of certain existing materials.

1.05 SUBMITTALS

A. Materials List: Submit a list identifying the specific type of material that will be used for each piping system. Include pipe, pipefittings, valves and joints. Include the basic designation of the publication applicable for each type of material and method.

B. Refrigeration Piping Requirements: Submit a letter from the refrigeration equipment manufacturer stating that the refrigeration piping system, as shown on the contract documents, is acceptable for the equipment the manufacturer proposes to furnish, or submit drawings prepared by an authorized representative of the refrigeration equipment manufacturer.

PART 2 – PRODUCTS

2.01 MATERIALS

A. Refrigerant (RS/RL/RHG) Piping.

1. System Design Pressure: 300 psig.

2. Piping carrying Refrigerants shall be ACR copper.

3. ACR Copper Refrigerant Piping:

a. Piping, 3" and smaller: Type ACR annealed copper tubing, ASTM B280, ANSI H23.1. (Below Grade in Conduit)

b. Piping, 3" and smaller: Type ACR hard-drawn copper tubing, ASTM B88, ANSI H23.1. (Above Ground only)

c. Fittings, 3" and smaller, all types, wrought copper: ASTM B16.22, ANSI B16.22. All 90° elbows shall be the long radius type.

d. Brazing: Contractors Option:

1) 5% silver, 6% phosphorus, balance copper, 1190°F melting point. AWS A5.8 number BCuP -3. J.W. Harris Stay-Silv□ 5 or equal.

2) 15% silver, 5% phosphorus, balance copper, 1190°F melting point. AWS 5.8 number BCuP-5. J.W. Harris Stay-Silv□ 15 or equal.

3) 6% silver, 6.1% phosphorus, balance copper, 1190°F melting point. QQ-B-654A number BCuP -5. J.W. Harris Dynaflow□ 5 or equal

e. Unions used shall be specifically designed for refrigeration piping.

2.02 VALVES AND SPECIALTIES

A. Solenoid Valves:

1. Liquid line shut off.

2. Normally closed.

3. Manual lift stem.

4. Pilot operated.

5. Synthetic seat for permanent tight shut off.

6. 120 volt solenoid coil (interchangeable).

7. Top grade brass, bronze and/or semi-steel body materials.

8. Acceptable Manufacturers: Sporlan, Alco, Hubbell, Phillips, or Henry.

B. Filter Drier:

1. Replaceable core type.

2. Heavy steel, cadmium plated with external coat of paint.

3. All internal parts cadmium plated.

4. Outlet seal gasket with spring to prevent bypassing.

5. Copper fittings brazed to steel shell, suitable for soldering with Sil-Fos or Phos-Copper solder.

6. Molded porous core elements.

7. Tie rod assembly to permit external assembly with one piece insert.

8. Bolt and nut attachment.

9. Size for refrigerant capacity and tonnage at 2 psi pressure drop.

10. Acceptable Manufacturers: Sporlan, Alco, Hubbell, Phillips, or Henry.

C. Moisture and Liquid Indicators:

1. Suitable for R-410A.

2. Accurately calibrated to change color for indication of moisture.

3. Large full view sight glass.

4. Removable indicator element for sizes 1-3/8" and up. Remove before soldering.

5. Full line size for liquid lines up to 2-1/8" O.D. 3/8" bypass indicator with preformed installation kit on larger sizes.

6. Acceptable Manufacturers: Sporlan, Alco, Hubbell, Phillips, or Henry.

D. Sight Glasses:

1. Similar to Sporlan "See-all" moisture and liquid indicator with solder type connections.

2. Install sight glass of the same size as the liquid line.

E. Miscellaneous Valves and Accessories:

1. Drain valves for all pressure vessels.

2. Dual pressure relief valves with manifold for all pressure vessels.

3. Refrigerant service valves where indicated.

F. Pressure - Temperature Test Ports and Test Kit:

1. Brass or stainless steel body with threaded cap and gasket.

2. Two self closing valves with intermediate pocket for added pressure protection.

3. Pressure temperature test kits consisting of 0- 150 psi pressure gauge with adapter, 25-125°F testing thermometer, 0-220°F testing thermometer, gauge adopted and protective carrying case (two required).

G. Thermometers:

1. Red reading type, glass front, iron or phenol case, adjustable pattern, separable socket.

2. Shall have 9 inch scale and 12 inch case.

3. Operating range shall occur in middle half of total range

4. Acceptable Manufacturers: Mueller, Taylor, or Rochester.

H. Gauges:

1. Liquid pressure gauges constructed with bronze tube, stainless steel movement, white dial, black micrometer, adjustable pointer, iron case with black flange iron or phenol screwed ring, bottom connection.

2. Case diameter size shall be 4-1/2 inches minimum.

3. Operating range shall occur in middle half of total gauge range.

4. Provide needle valve for all gauges.

5. Acceptable Manufacturers: Crosby-Ashton Type AAO, Ashcroft, or Lonegran

I. Refrigerant Charge: Complete operating charge of R-410A.

J. High pressure receiver, designed and constructed for 300 psi design working pressure with liquid seal float control, automatic liquid feed valve, drain and equalizer connections, liquid line filter-drier, moisture indicator, three service and bypass valves, charge valve and manual purge valve.

K. Locking Refrigerant Caps: Precision machined from high grade brass surrounded by a protective aluminum shroud. Provide a 1-year warranty. Provide one multi key per project to maintenance personnel.

PART 3 – EXECUTION

3.01 INSTALLATION

A. General:

1. Furnish and install piping, fittings and appurtenances required to complete the piping systems shown on the drawings. Elbows shall be long radius type. Tees may not be field fabricated.

2. Run piping to true alignment, generally parallel or perpendicular to building walls, floors and ceilings, and with uniform grades and spacing, so as to present a neat and workmanlike appearance.

3. Care shall be paid to the exact locations of piping with respect to equipment, ducts, conduits, slabs, beams, lighting fixtures, columns, ceiling suspension systems, etc. to provide maximum access to mechanical and electrical equipment in the building. Close coordination and cooperation shall be exercised with other trades in locating the piping in the best interests of the Owner. The drawings and specifications covering other work to be done in the building shall be carefully studied and arrangements made to avoid conflict.

4. Not all necessary pipe offsets are indicated on the drawings because of the small scale. The various runs of piping to be installed shall be studied and adjustments made in exact routings as may be required for proper installation.

5. Conflicts arising during the erection of piping shall be brought to the attention of the Owner's Representative. No improvising or field changes will be permitted without the approval of the Owner's Representative.

6. Use full lengths of pipe wherever possible. Short lengths of pipe with couplings will not be permitted. Cut to exact measurement and install without forcing or spring unless otherwise shown on the drawings or specified.

7. Avoid tool marks and unnecessary pipe threads. Burrs formed when cutting pipe shall be removed by reaming. Before installing any pipe, care shall be taken that the inside is thoroughly cleaned and free of cuttings and foreign matter. Measures shall be taken to preserve this cleanliness after erection.

8. Arrange pipe connections to valves and specialties so that there is clearance for easy removal of the valve or specialty from the line, and also for the removal of the valve bonnet and interior, and the specialty top and bottom and interior, except where otherwise approved by the Owner's Representative.

9. Erect piping to obtain sufficient flexibility and to prevent excessive stresses in materials and excessive bending movements at joints or connections to equipment. Make allowances throughout for expansion and contraction of piping. Provide each riser and horizontal run of piping with expansion loops, expansion joints, or expansion compensators where indicated and required. Securely anchor and adequately guide pipe as required or where indicated to force expansion to the expansion device without bending, binding, or misalignment of pipe. Branch connections from mains to risers shall be made with ample swing or offset to avoid undue strain on fittings or short pipe lengths. Where indicated, in lieu of expansion loops, expansion joints, or expansion compensators, horizontal runs of pipe shall be anchored at approximately midway of the run to force expansion, evenly divided, toward the mains and risers to provide for expansion and contraction of piping. Flexibility shall be provided by installing one or more turns in the line so that piping will spring enough to allow for expansion without straining.

10. Installed piping shall not interfere with the operations or accessibility of doors or windows and shall not encroach on aisles, passageways and equipment, and shall not interfere with the servicing or maintenance of any equipment. Adjacent pipelines shall be grouped in the same horizontal or vertical plane.

11. Where lines are purposely pitched for drainage, an accurate grade shall be maintained. No lines shall be supported in such a manner as to permit deflection, due to gravity, sufficient to pocket the lines when full of liquid. Grade mains as indicated by arrows on the drawings and in accordance with gradient as indicated in attached Piping Schedule.

12. Piping found to have water hammer or other objectionable vibrations which cannot be eliminated by proper grading or other natural means, shall be braced, trapped or hung with shock absorbing hangers and equipped with air chambers, mechanical shock absorbers, and flexible pipe connections or otherwise silenced using approved means.

13. Use building steel wherever possible for supporting pipe hangers. Main structural steel shall not be drilled, cut or burned for hangers without the approval of the Owner's Representative. Expansion bolts shall be used only upon the approval of the Owner's Representative.

14. Install unions or flanges in piping connections to equipment, regulating valves, and wherever necessary to facilitate the dismantling of piping and/or removal of valves and other items requiring maintenance.

15. Avoid bushings. Reducing fittings shall be used wherever practical.

16. The drawings indicate the size of piping and connections, and if certain sizes are omitted or unclear, obtain additional information before proceeding.

17. The piping drawings have been worked out with a view to the most economical installation, taking into consideration accessibility and appearances, and the Contractor must follow the drawings accurately and if it is found impractical to install the work in accordance with the drawings and specifications, the Contractor shall notify the Owner's Representative before making any changes and get their approval or revised drawings before proceeding with the work. Verify all measurements on the job before cutting pipes or having piping fabricated, and be responsible for the correct location of all pipe connections, also check sizes and standard of outlets on the equipment, including the dimensions and drilling of flanges, etc.

18. Copper tubing shall not be mixed in any one run of piping.

19. Change in direction shall be made with fittings, except that bending of copper pipe 4 inches and smaller will be permitted, provided a pipe bender is used and wide sweep bends are formed. The center-line radius of bends shall be not less than 6 diameters of the pipe. Bent pipe showing kinks, wrinkles, flattening, or other malformations is not acceptable.

20. Threaded joints shall be made with tapered threads in accordance with ANSI B2.1, and made tight with an approved pipe thread joint compound or material, applied to the male threads only. Use compounds sparingly and apply with caution to ensure that compounds do not enter piping systems. When pipe joint is made up a maximum of 3 threads shall be visible.

21. Joints for plastic pipe shall be made in accordance with PPI Piping Manual.

22. Connections between ferrous and nonferrous metallic pipe shall be made with dielectric unions or flanges.

23. Connections between plastic and metallic pipe, between plastic and glass pipe and between metallic and glass pipe, shall be made with transition fittings manufactured for the specific purpose.

24. Unions and flanges shall not be concealed in walls, partitions, or above inaccessible ceilings.

25. Refrigerant piping penetrations to condensing units shall be elevated above pad, and covered with protective guttering designed to protect piping.

B. Valve and Specialties Applications

1. Install service valves for gage taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.

2. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.

3. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at top.

4. Install thermostatic expansion valves as close as possible to distributors on evaporators.

    a. Install valve so diaphragm case is warmer than bulb.

    b. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line. Verify proper location for the bulb with the valve manufacturer

    c. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.

5. Install safety relief valves where required by ASME Boiler and Pressure Vessel Code. Pipe safety relief-valve discharge line to outside according to ASHRAE 15.

6. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube on each circuit.

7. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for device being protected:

    a. Solenoid valves.

    b. bhermostatic expansion valves.

c. Hot-gas bypass valves.

d. Compressor.

8. Install filter dryers in liquid line between compressor and thermostatic expansion valve on each circuit.

9. Install receivers sized to accommodate pump-down charge.

10. Install flexible connectors at compressors.

11. Locking Refrigerant Caps: Provide at all exterior refrigerant service access ports (Schrader valves).

12. Install gauges with dial in vertical position. Locate between shut-off valve and equipment directly adjacent to equipment within normal visual range of operator standing on floor.

13. Provide gauges where shown on drawings, including the following locations:

a. Ice builders; leaving each builder on the pumped liquid return header.

b. Barrel chiller; entering and leaving the pumped liquid lines.

c. Compressor oil coolers; entering and leaving condenser water lines.

d. Evaporative condenser; entering and leaving refrigerant lines.

e. Refrigerant pumps; entering and leaving the pumped liquid lines.

14. Provide nickel plated brass escutcheons or floor plates, around pipes piercing floors and walls in finished spaces. Fit around insulation or around pipe if uninsulated. Secure to pipe with setscrew. Provide deep escutcheon where sleeve projects beyond finished surface

C. Refrigerant Systems Additional Requirements:

1. Installation shall be in accordance with ANSI B31.5 Refrigeration Piping, unless specified otherwise herein.

2. Brazing procedures and operators shall be qualified in accordance with the requirements of Section IX of the ASME Boiler and Pressure Vessel Code.

3. Refrigerant pipeline accessories that may be damaged by heat shall be disassembled prior to joint brazing. Reassemble accessories after joint brazing operations are completed.

4. Joints shall be made with solder-type fittings. The outside surface of the tube where engaged in the fitting, and the inside surface of the fitting in contact with the tube, shall be cleaned with an abrasive material before brazing. Self-cleaning compounds are not allowed. Care shall be taken to prevent annealing of tube and fittings when making connections. Brazed joints shall be made with flux and the previously specified silver-brazing alloy. The brazing alloy shall be applied and drawn through the full fitting length. Excess brazing alloy shall be wiped from the joint before the brazing alloy hardens. Joints shall be made with heat applied uniformly around the entire circumference of the tube and fittings. Remove all excess flux for a clear visual inspection of all brazed connections.

5. Refrigerant piping installed below concrete slab- on-grade shall be installed in continuous runs without joints, and shall be encased in PVC plastic conduit. Ends of conduit shall be sealed watertight.

3.02 BRAZING AND SOLDERING

A. Operator and Procedure Qualifications: All brazing operators and procedures shall be qualified in accordance with the requirements of Section IX of the ASME Boiler and Pressure Vessel Code.

B. Brazing: Silver braze joints in accordance with MSS-SP-73 "Silver Brazing Joints for Wrought and Cast Solder Joint Fittings".

C. Soldering: Joints in copper tubing shall be made with solder- type fittings. Outside surface of the tube where engaged in the fitting, and inside surface of the fitting in contact with the tube, shall be cleaned with an abrasive material before soldering. Self- cleaning compounds shall not be used. Care shall be taken to prevent annealing of tube and fittings when making connections. The solder joint shall be made with flux and wire form solder, except brazed joints. The flux shall be a mildly corrosive liquid or a petroleum based paste containing chlorides of zinc and ammonium. Solder shall be applied and drawn through the full fitting length. Excess solder shall be wiped from joint before solder hardens. Joints in copper tube sizes 2-1/2 inches and larger shall be made with heat applied uniformly around the entire circumference of the tube and fittings by a multi-flame torch. Use of oxy-acetylene cutting torch in lieu of multi-flame torch is not permitted. Disassemble valves and other accessories that may be damaged by heat before soldering.

3.03 TESTING OF PIPING SYSTEMS:

A. Each piping system, after erection, shall be subjected to a pressure test. The test requirements shall be as follows:

1. General: Furnish everything required for the tests. Notify Architect/Engineer at least 48 hours before any testing is performed. Independent Agent/Owner shall verify pressure test and sign off. Report to be furnished to Architect/Engineer.

2. Testing shall be performed at the completion of each phase of the project.

3. Refrigerant Piping Systems shall be tested with dry carbon dioxide, or nitrogen, at 315 psig for the high side, and at 245 psig for the low side. If leaks are to be detected by use of an electronic halogen detector, or a halide torch, the system shall be pressurized with refrigerant gas prior to introduction of dry carbon dioxide or nitrogen into the system. Pre-charging of system with refrigerant gas is not necessary for soap bubble leak detection method.

4. Leaks, if any, shall be located, repaired, and retested in accordance with the test method specified for the system in which the leaks are located.

5. Prior to testing a system, the Contractor shall provide the proper Building Official and the Owner's Representative with not less than 72 hours' notice of the proposed test. The Contractor shall obtain approval of the test results. Where written approval is required, the Contractor shall obtain such written approval, and submit a copy of the approval. Work requiring testing shall not be covered, or otherwise concealed, until testing is completed and approval is granted. Work, or portions of work, that is altered in any way after testing and approval shall be retested, witnessed, and approval obtained. Systems requiring hydrostatic tests shall be protected from damage caused by freezing. After tests are completed drain all sections of pipe, including traps, or fill undrained sections and traps with antifreeze solution. Vent all high points to release vacuum and ensure complete drainage of closed systems, and blow out piping with compressed air to remove trapped water. Duration of tests, unless specified otherwise, shall be the time required to examine each joint in the system being tested. During tests, isolate system components that have test pressures less than pressures specified for system tests. Use clean soapy water applied to exterior of joints to locate leaks in systems using compressed air, dry carbon dioxide, or nitrogen, under positive pressure as a test medium.

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SECTION 15738

SPLIT-SYSTEM AIR-CONDITIONERS

PART 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.

1.02 SUMMARY

A. Section includes split-system air-conditioning consisting of separate evaporator-fan and compressor-condenser components.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

2. Wiring Diagrams: For power, signal, and control wiring.

1.04 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Warranty: Sample of special warranty.

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.

1.06 MATERIALS MAINTENANCE 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. Filters: One set(s) for each air-handling unit.

1.07 QUALITY ASSURANCE

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:

1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."

2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Ventilation Rate Procedures," and Section 7 - "Construction and Startup."

C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

1.08 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-Place Concrete."

B. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.09 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.

1. Warranty Period:

a. For Compressor: Two year(s) from date of Substantial Completion.

b. For Parts: One year from date of Substantial Completion.

c. For Labor: One year from date of Substantial Completion.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

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

1. Carrier Corporation; Home Comfort and HVAC Building & Industrial Systems.

1. Daikin Applied; a division of Daikin Comfort Technologies North America.

2. Trane; a business of American Standard companies.

2.02 INDOOR UNITS (6 TONS (21 KW) OR MORE)

A. Floor-Mounted, Evaporator-Fan Components:

1. Cabinet: Enameled steel with removable panels on front and ends.

a. Insulation: Faced, glass-fiber duct liner.

2. Condensate Drain Pans:

a. Fabricated with one percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and humidifiers, and to direct water toward drain connection.

1) Depth: A minimum of 2 inches (50 mm) deep.

b. Single-wall, galvanized-steel sheet.

c. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on both ends of pan.

1) Minimum Connection Size: NPS 1 (DN 25).

d. Pan-Top Surface Coating: Asphaltic waterproofing compound.

e. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

3. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 206/110.

4. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements; with refractory ceramic support bushings, automatic-reset thermal cutout, built-in magnetic contactors, manual-reset thermal cutout, airflow proving device, and one-time fuses in terminal box for overcurrent protection.

5. Fan: Direct drive, centrifugal.

6. Fan Motors:

a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 15187 "Common Motor Requirements for HVAC Equipment."

b. Enclosure Type: Totally enclosed, fan cooled.

c. NEMA Premium (TM) efficient motors as defined in NEMA MG 1.

d. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.

e. Mount unit-mounted disconnect switches on exterior of unit.

7. Air Filtration Section:

a. General Requirements for Air Filtration Section:

1) Comply with NFPA 90A.

2) Filter-Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lifted out from access plenum.

b. Extended-Surface, Disposable Panel Filters:

1) Factory-fabricated, dry, extended-surface type.

2) Thickness: 2 inches (50 mm).

3) MERV according to ASHRAE 52.2: 8.

4) Media: Fibrous material formed into deep-V-shaped pleats and held by self-supporting wire grid.

5) Media-Grid Frame: Nonflammable cardboard.

2.03 OUTDOOR UNITS (6 TONS (21 KW) OR MORE)

A. Air-Cooled, Compressor-Condenser Components:

1. Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.

2. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation device. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.

a. Compressor Type: Scroll.

b. Two-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.

c. Refrigerant: R-410A.

d. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid subcooler. Comply with ARI 206/110.

3. Fan: Aluminum-propeller type, directly connected to motor.

4. Motor: Permanently lubricated, with integral thermal-overload protection.

5. Low Ambient Kit: Permits operation down to 45 deg F (7 deg C).

6. Mounting Base: Polyethylene.

2.04 ACCESSORIES

A. Thermostat: Low voltage with subbase to control compressor and evaporator fan.

B. Refrigerant Piping and Accessories: Provide refrigerant piping and accessories in accordance with Section 15187 00 Refrigerant Piping and Manufacturer's published instructions.

2.05 INSTALLATION

A. Install units level and plumb.

B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

C. Install ground-mounted, compressor-condenser components on 4-inch- thick, reinforced concrete base that is 4 inches larger, on each side, than unit. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-Place Concrete." Coordinate anchor installation with concrete base.

D. Install ground-mounted, compressor-condenser components on polyethylene mounting base.

E. Install and connect pre-charged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

F. Provide manufacturer's mounting brackets or shelf for condensate pump installation.

2.06 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.

C. Duct Connections: Duct installation requirements are specified in Division 15 Section "Metal Ducts" Drawings indicate the general arrangement of ducts. Connect supply and return ducts to split-system air-conditioning units with flexible duct connectors. Flexible duct connectors are specified in Division 15 Section "Air Duct Accessories."

2.07 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

2. 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. Remove and replace malfunctioning units and retest as specified above.

C. Prepare test and inspection reports.

2.08 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

2.09 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION

SECTION 15811

METAL DUCTS

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:

1. Single-wall rectangular ducts and fittings.

2. Single-wall round ducts and fittings.

3. Sheet metal materials.

4. Sealants and gaskets.

5. Hangers and supports.

1.03 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.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of the following products:

1. Sealants and gaskets.

B. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.

2. Factory- and shop-fabricated ducts and fittings.

3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.

4. Elevation of top of ducts.

5. Dimensions of main duct runs from building grid lines.

6. Fittings.

7. Reinforcement and spacing.

8. Seam and joint construction.

9. Penetrations through fire-rated and other partitions.

10. Equipment installation based on equipment being used on Project.

11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.

12. Hangers and supports, including methods for duct and building attachment and vibration isolation.

C. Delegated-Design Submittal:

1. Sheet metal thicknesses.

2. Joint and seam construction and sealing.

3. Reinforcement details and spacing.

4. Materials, fabrication, assembly, and spacing of hangers and supports.

5. Design Calculations: Calculations for selecting hangers and supports.

1.05 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. Field quality-control reports.

1.06 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

B. 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.

C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

PART 2 – PRODUCTS

2.01 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."

2.02 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 Inchesin 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 inchesin diameter with butt-welded longitudinal seams.

2. Fabricate flat-oval ducts larger than 72 inchesin width (major dimension) 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."

2.03 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. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.

D. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.

E. 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.

F. 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 .

2.04 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.

6. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

D. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

E. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.

2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.

3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.05 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

3.01 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 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 Division 23 Section "Air Duct Accessories" for fire and smoke dampers.

L. Where ducts pass through fire- or smoke-rated partitions or walls, but do not require a damper, seal and firestop penetration around duct to maintain rating.

M. Protect duct interiors from moisture, construction debris and dust, and other foreign materials.

3.02 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. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

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.

1.1 DUCT SEALING

F. 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."

3.03 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.

1. Where practical, install concrete inserts before placing concrete.

2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.

3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.

4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.

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 maximum intervals 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.

3.04 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Division 23 Section "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.05 PAINTING

A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Division 09 painting Sections.

3.06 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. Test the following systems:

a. Supply Ducts with a Pressure Class of 3-inch wg or Higher: Test representative duct sections totaling no less than 100 percent of total installed duct area for each designated pressure class.

3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.

4. Test for leaks before applying external insulation.

5. 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.

6. Give seven days' advance notice for testing.

C. Duct system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.07 START UP

A. Air Balance: Comply with requirements in Division 23 Section "Testing, Adjusting, and Balancing for HVAC."

3.08 DUCT SCHEDULE

A. Supply Ducts: Galvanized steel.

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:

a. Pressure Class: Positive 1-inch wg.

b. Minimum SMACNA Seal Class: C.

c. SMACNA Leakage Class for Rectangular: 24.

d. SMACNA Leakage Class for Round and Flat Oval: 12.

2. Ducts Connected to Constant-Volume Air-Handling Units:

a. Pressure Class: Positive 2-inch wg .

b. Minimum SMACNA Seal Class: B.

c. SMACNA Leakage Class for Rectangular: 12.

d. SMACNA Leakage Class for Round and Flat Oval: 6.

B. Return Ducts: Galvanized steel.

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:

a. Pressure Class: Positive or negative 1-inch wg .

b. Minimum SMACNA Seal Class: C.

c. SMACNA Leakage Class for Rectangular: 24.

d. SMACNA Leakage Class for Round and Flat Oval: 12.

2. Ducts Connected to Air-Handling Units:

a. Pressure Class: Positive or negative 2-inch wg.

b. Minimum SMACNA Seal Class: B.

c. SMACNA Leakage Class for Rectangular: 12.

d. SMACNA Leakage Class for Round and Flat Oval: 6.

C. Exhaust Ducts: Stainless steel.

1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:

a. Pressure Class: Negative 1-inch wg .

b. Minimum SMACNA Seal Class: C 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.

D. Intermediate Reinforcement:

1. Galvanized-Steel Ducts: Galvanized steel.

2. Stainless-Steel Ducts:

a. Exposed to Airstream: Match duct material.

b. Not Exposed to Airstream: Match duct material.

E. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

a. Velocity 1000 fpm or Lower:

1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.

2) Mitered Type RE 4 without vanes.

b. Velocity 1000 to 1500 fpm :

1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.

c. Velocity 1500 fpm or Higher:

1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.

2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.

3. 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 and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.

1) Radius-to Diameter Ratio: 1.5.

b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.

c. Round Elbows, 14 Inches and Larger in Diameter: Standing seam.

F. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."

a. Rectangular Main to Rectangular Branch: 45-degree entry.

b. Rectangular Main to Round Branch: Spin in.

2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.

a. Velocity 1000 fpm or Lower: 90-degree tap.

b. Velocity 1000 to 1500 fpm: Conical tap.

c. Velocity 1500 fpm or Higher: 45-degree lateral.

END OF SECTION

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SECTION 15820

DUCT ACCESSORIES

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section includes the following:

1. Backdraft dampers.

2. Flange Connectors

1.03 SUBMITTALS

A. Product Data: For the following:

1. Backdraft dampers.

2. Flange Connector

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loadings, required clearances, method of field assembly, components, location, and size of each field connection. Detail the following:

1. Special fittings and manual- and automatic-volume-damper installations.

2. Fire- and smoke-damper installations, including sleeves and duct-mounted access doors and panels.

C. Product Certificates: Submit certified test data on dynamic insertion loss; self-noise power levels; and airflow performance data, static-pressure loss, dimensions, and weights.

1.04 QUALITY ASSURANCE

A. NFPA Compliance: Comply with the following NFPA standards:

1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."

2. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

PART 2 – PRODUCTS

2.01 SHEET METAL MATERIALS

A. Galvanized, Sheet Steel: Lock-forming quality; ASTM A 653, G90 coating designation; mill-phosphatized finish for surfaces of ducts exposed to view.

B. Carbon-Steel Sheets: ASTM A 366/A 366M, cold-rolled sheets, commercial quality, with oiled, exposed matte finish.

C. Aluminum Sheets: ASTM B 209, Alloy 3003, Temper H14, sheet form; with standard, one-side bright finish for ducts exposed to view and mill finish for concealed ducts.

D. Extruded Aluminum: ASTM B 221, Alloy 6063, Temper T6.

E. Reinforcement Shapes and Plates: Galvanized steel reinforcement where installed on galvanized, sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for 36-inch length or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.02 BACKDRAFT DAMPERS

A. Description: Suitable for horizontal or vertical installations.

B. Frame: 0.052-inch thick, galvanized, sheet steel, with welded corners and mounting flange.

C. Blades: 0.050-inch thick aluminum sheet.

D. Blade Seals: Vinyl 01, Neoprene.

E. Blade Axles: Galvanized steel.

F. Tie Bars and Brackets: Galvanized steel.

G. Return Spring: Adjustable tension.

2.03 FLANGE CONNECTORS

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. Ductmate Industries, Inc.

2. Nexus PDQ; Division of Shilco Holdings Inc.

3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.

C. Material: Galvanized steel.

D. Gage and Shape: Match connecting ductwork.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install duct accessories according to applicable details shown in SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for metal ducts and NAIMA's "Fibrous Glass Duct Construction Standards" for fibrous-glass ducts.

B. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

C. Set dampers to fully open position before testing, adjusting, and balancing.

D. Provide test holes at fan inlet and outlet and elsewhere as indicated.

3.02 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.

END OF SECTION

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SECTION 15838

POWER VENTILATORS

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section includes the following:

1. Centrifugal roof ventilators.

1.03 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base fan-performance ratings on actual Project site elevations.

B. Operating Limits: Classify according to AMCA 99.

1.04 SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:

1. Certified fan performance curves with system operating conditions indicated.

2. Certified fan sound-power ratings.

3. Motor ratings and electrical characteristics, plus motor and electrical accessories.

4. Material thickness and finishes, including color charts.

5. Dampers, including housings, linkages, and operators.

6. Roof curbs.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.

C. Field quality-control test reports.

D. Operation and Maintenance Data: For power ventilators to include in emergency, operation, and maintenance manuals.

1.05 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.

C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

D. UL Standard: Power ventilators shall comply with UL 705.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver fans as factory-assembled unit, to the extent allowable by shipping limitations, with protective crating and covering.

B. Disassemble and reassemble units, as required for moving to final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

1.07 COORDINATION

A. Coordinate size and location of structural-steel support members.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 7 Section "Roof Accessories."

1.08 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Belts: One set(s) for each belt-driven unit.

PART 2 – PRODUCTS

2.01 CENTRIFUGAL ROOF VENTILATORS

A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

1. Greenheck.

2. Loren Cook Company.

3. Penn Ventilation.

B. Description: Direct- or belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.

C. Housing: Removable, spun-aluminum, dome top and outlet baffle; square, one-piece, aluminum base with venturi inlet cone.

1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains and grease collector.

2. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.

D. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.

E. Belt-Driven Drive Assembly: Resiliently mounted to housing, with the following features:

1. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.

2. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.

3. Pulleys: Cast-iron, adjustable-pitch motor pulley.

4. Fan and motor isolated from exhaust airstream.

F. Accessories:

1. Disconnect Switch: Non-fusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.

2. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.

G. Roof Curbs: Galvanized steel; mitered and welded corners and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.

1. Configuration: Self-flashing without a cant strip, with mounting flange.

2. Overall Height: 12 inches.

2.02 MOTORS

A. Enclosure Type: Totally enclosed, fan cooled OR Electronically Commutated Motor (ECM).

2.03 SOURCE QUALITY CONTROL

A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

PART 3 – EXECUTION

3.01 INSTALLATION

A. Install power ventilators level and plumb.

B. Secure roof-mounting fans to roof curbs with cadmium-plated hardware. Refer to Division 7 Section "Roof Accessories" for installation of roof curbs.

C. Install units with clearances for service and maintenance.

D. Label units according to requirements specified in Division 23 Section "Mechanical Identification."

3.02 CONNECTIONS

A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 23 Section "Duct Accessories."

B. Install ducts adjacent to power ventilators to allow service and maintenance.

C. Ground equipment according to Division 26 Section "Grounding and Bonding."

D. Connect wiring according to Division 26 Section "Conductors and Cables."

3.03 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. Verify that shipping, blocking, and bracing are removed.

2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.

3. Verify that cleaning and adjusting are complete.

4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.

5. Adjust belt tension.

6. Adjust damper linkages for proper damper operation.

7. Verify lubrication for bearings and other moving parts.

8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.

9. Disable automatic control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.

10. Shut unit down and reconnect automatic control operators.

11. Remove and replace malfunctioning units and retest as specified above.

B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.04 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Refer to Division 23 Section "Testing, Adjusting, and Balancing" for testing, adjusting, and balancing procedures.

D. Replace fan and motor pulleys as required to achieve design airflow.

E. Lubricate bearings.

END OF SECTION

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SECTION 15855

DIFFUSERS, REGISTERS, AND GRILLES

PART 1 – GENERAL

1.01 WORK INCLUDED

A. Registers/grilles.

1.02 REFERENCES

A. ADC 1062 - Certification, Rating and Test Manual.

B. ANSI/NFPA 90A - Installation of Air Conditioning and Ventilating Systems.

C. ANSI/ASHRAE 70-1991 – Method of Testing for Rating Performance of Air Outlets and Intakes.

D. ARI 650 - Air Outlets and Inlets.

E. ASHRAE 70 - Method of Testing for Rating the Air Flow Performance of Outlets and Inlets.

F. SMACNA - Low Pressure Duct Construction Standard.

1.03 QUALITY ASSURANCE

A. Test and rate performance of air outlets and inlets in accordance with ADC Equipment Test Code 1062 and ASHRAE 70.

1.04 REGULATORY REQUIREMENTS

A. Conform to ANSI/NFPA 90A.

1.05 SUBMITTALS

A. Provide product data for items required for this project.

B. Submit schedule of outlets and inlets indicating type, size, location, application, and noise level.

C. Review requirements of outlets and inlets as to size, finish, and type of mounting prior to submitting product data and schedules of outlets and inlets.

D. Submit manufacturer's installation instructions.

PART 1 - PRODUCTS

1.06 REGISTERS

A. Adjustable Blade Face Register:

1. Material: Steel.

2. Finish: Baked enamel, white.

3. Face Blade Arrangement: Horizontal spaced 3/4 inch (19 mm) apart.

4. Core Construction: Integral.

5. Rear-Blade Arrangement: Vertical spaced 3/4 inch (19 mm) apart.

6. Frame: 1-1/4 inches (32 mm) wide.

7. Mounting: Countersunk screw.

8. Damper Type: Multi-shutter or adjustable opposed blade.

9. Accessories: Front-blade gang operator.

B. Fixed Face Register:

1. Material: Steel.

2. Finish: Baked enamel, white.

3. Face Blade Arrangement: Horizontal spaced 3/4 inch (19 mm) apart.

4. Core Construction: Integral.

5. Frame: 1-1/4 inches (32 mm) wide.

6. Mounting: Countersunk screw.

1.07 GRILLES

A. Adjustable Blade Face Grille:

1. Material: Steel.

2. Finish: Baked enamel, white.

3. Face Blade Arrangement: Horizontal spaced 3/4 inch (19 mm) apart.

4. Core Construction: Integral.

5. Rear-Blade Arrangement: Vertical spaced 3/4 inch (19 mm) apart.

6. Frame: 1-1/4 inches (32 mm) wide.

7. Mounting: Countersunk screw Concealed Lay in.

8. Accessories: Front-blade gang operator.

A. Fixed Face Grille:

1. Material: Steel.

2. Finish: Baked enamel, white.

3. Face Blade Arrangement: Horizontal; spaced 3/4 inch (19 mm) apart.

4. Core Construction: Integral.

5. Frame: 1-1/4 inches (32 mm) wide.

6. Mounting: Countersunk screw.

B. Perforated Face Grille:

1. Material: Aluminum.

2. Finish: Baked enamel, white.

3. Face: Perforated (19 mm).

4. Core Construction: Integral or removeable.

5. Frame: 1-1/4 inches (32 mm) wide.

6. Mounting: Countersunk screw or lay-in for T-bar ceiling.

PART 2 – EXECUTION

2.01 INSTALLATION

A. Install items in accordance with manufacturers' instructions.

B. Check location of outlets and inlets and make necessary adjustments in position to conform with architectural features, symmetry, and lighting arrangement.

C. Install registers and grilles to ductwork with air tight connection.

D. Provide balancing dampers on duct take-off to grilles and registers, regardless of whether dampers are specified as part of the grille and register assembly.

E. Use concealed anchorages where possible. Provide brass or lead washers fitted to screws where required to protect metal surfaces and to make a weathertight connection.

F. Form closely fitted joints with exposed connections accurately located and secured.

G. Repair finishes damaged by cutting, welding, soldering, and grinding. Restore finishes so no evidence remains of corrective work. Return items that cannot be refinished in the field to the factory, make required alterations, and refinish entire unit or provide new units.

H. Protect galvanized and nonferrous-metal surfaces from corrosion or galvanic action by applying a heavy coating of bituminous paint on surfaces that will be in contact with concrete, masonry, or dissimilar metals.

END OF SECTION

SECTION 15900

INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section includes open protocol DDC control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-wired controls, lighting in new and existing facilities, generators, freezer, coolers and make-up water meter.

1.03 DEFINITIONS

A. DDC: Direct digital control.

B. I/O: Input/output.

C. BACnet: ASHRAE Standard 135/2004 open protocol standards

D. MS/TP: Master slave/token passing. BACnet standard for 485 communications

E. PC: Personal computer.

F. PID: Proportional plus integral plus derivative.

G. LonWorks: A control network technology platform for designing and implementing interoperable control devices and networks.

1.04 SYSTEM PERFORMANCE

A. Comply with the following performance requirements:

1. Graphic Display: Display graphic with minimum 20 dynamic points with current data within 10 seconds.

2. Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 8 seconds.

3. Object Command: Reaction time of less than two seconds between operator command of a binary object and device reaction.

4. Object Scan: Transmit change of state and change of analog values to control units or workstation within six seconds.

5. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within five seconds of each other.

6. Program Execution Frequency: Run capability of applications as often as five seconds, but selected consistent with mechanical process under control.

7. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.

8. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:

B. Water Temperature: Plus or minus 1 deg F.

C. Water Flow: Plus or minus 5 percent of full scale.

D. Water Pressure: Plus or minus 2 percent of full scale.

E. Space Temperature: Plus or minus 0.35 deg F.

F. Ducted Air Temperature: Plus or minus 0.35 deg F.

G. Outside Air Temperature: Plus or minus 0.35 deg F.

H. Dew Point Temperature: Plus or minus 0.35 deg F.

I. Temperature Differential: Plus or minus 0.25 deg F.

J. Relative Humidity: Plus or minus 2 percent.

K. Airflow (Measuring Stations): Plus or minus 5 percent of full scale.

L. Airflow (Terminal): Plus or minus 10 percent of full scale.

M. Air Pressure (Ducts): Plus or minus 0.1-inch wg.

N. Carbon Dioxide: Plus or minus 50 ppm.

O. Electrical: Plus or minus 5 percent of reading.

1.05 SUBMITTALS

A. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.

1. DDC System Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for operator workstation equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.

2. Control System Software: Include technical data for operating system software, operator interface, color graphics, and other third-party applications.

3. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Bill of materials of equipment indicating quantity, manufacturer, and model number.

2. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.

3. Wiring Diagrams: Power, signal, and control wiring.

4. Details of control panel faces, including controls, instruments, and labeling.

5. Written description of sequence of operation.

6. Schedule of dampers including size, leakage, and flow characteristics.

7. Schedule of valves including flow characteristics.

8. DDC System Hardware:

   a. Wiring diagrams for control units with termination numbers.

   b. Schematic diagrams and floor plans for field sensors and control hardware.

   c. Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.

9. Control System Software: List of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule, and operator notations.

10. Controlled Systems:

a. Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.

b. Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.

c. Written description of sequence of operation including schematic diagram.

d. Points list.

C. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with ASHRAE 135 and that system is Open Protocol.

D. Software and Firmware Operational Documentation: Include the following:

1. Software operating and upgrade manuals.

2. Program Software Backup: On a magnetic media or compact disc, complete with data files.

3. Device address list.

4. Printout of software application and graphic screens.

5. Software license required by and installed for DDC workstations and control systems.

E. Software Upgrade Kit: For Owner to use in modifying software to suit future systems revisions or monitoring and control revisions.

F. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Maintenance instructions and lists of spare parts for each type of control device and compressed-air station.

2. Interconnection wiring diagrams with identified and numbered system components and devices.

3. Keyboard illustrations and step-by-step procedures indexed for each operator function.

4. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.

5. Calibration records and list of set points.

1.06 QUALITY ASSURANCE

A. Installer Qualifications: Automatic control system manufacturer's authorized representative who is trained and approved for installation of system components required for this Project.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with ASHRAE 135 (BACnet) for DDC system components.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.

B. System Software: Update to latest version of software at Project completion.

1.08 COORDINATION

A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.

B. Coordinate equipment with Division 16 Section "Lighting Controls" to achieve compatibility with equipment that interfaces with that system.

C. Coordinate equipment with Division 16 Section "Fire Detection and Alarm" to achieve compatibility with equipment that interfaces with that system.

D. Coordinate supply of conditioned electrical branch circuits for control units and operator workstation.

E. Coordinate equipment with Division 16 Section "Motor-Control Centers" to achieve compatibility with motor starters and annunciation devices.

PART 2 – PRODUCTS

2.01 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.02 CONTROL SYSTEM

A. Manufacturers:

1. Alerton Inc. (CSSI)

2. JCI Metasys

3. Trane

4. MC2 (Schneider Electric)

B. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected to distributed controllers operating in multiuser, multitasking environment on token-passing network and programmed to control mechanical systems. An operator workstation permits interface with the network via dynamic color graphics with each mechanical system, building floor plan, and control device depicted by point-and-click graphics.

2.03 DDC EQUIPMENT

A. Control Units: Modular, comprising processor board with programmable, nonvolatile, random-access memory; local operator access and display panel; integral interface equipment; and backup power source.

1. Units monitor or control each I/O point; process information; execute commands from other control units, devices, and operator stations; and download from or upload to operator workstation.

2. Stand-alone mode control functions operate regardless of network status. Functions include the following:

a. Global communications.

b. Discrete/digital, analog, and pulse I/O.

c. Monitoring, controlling, or addressing data points.

d. Software applications, scheduling, and alarm processing.

e. Testing and developing control algorithms without disrupting field hardware and controlled environment.

3. Standard Application Programs:

a. Electric Control Programs: Demand limiting, duty cycling, automatic time scheduling, start/stop time optimization, night setback/setup, on-off control

with differential sequencing, staggered start, antishort cycling, PID control, DDC with fine tuning, and trend logging.

b. HVAC Control Programs: Optimal run time, supply-air reset, and enthalpy switchover.

c. Chiller Control Programs: Control function of condenser-water reset, chilled-water reset, and equipment sequencing.

d. Programming Application Features: Include trend point; alarm processing and messaging; weekly, monthly, and annual scheduling; energy calculations; run-time totalization; and security access.

e. Remote communications.

f. Maintenance management.

g. Units of Measure: Inch-pound.

4. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.

5. ASHRAE 135 – BACnet Compliance: Control units shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.

6. LonWorks Compliance: Control units shall use LonTalk protocol and communicate using EIA/CEA 709.1 datalink/physical layer protocol.

B. Local Control Units: Modular, comprising processor board with electronically programmable, nonvolatile, read-only memory; and backup power source.

1. Units monitor or control each I/O point, process information, and download from or upload to operator workstation or diagnostic terminal unit.

2. Stand-alone mode control functions operate regardless of network status. Functions include the following:

a. Global communications.

b. Discrete/digital, analog, and pulse I/O.

c. Monitoring, controlling, or addressing data points.

3. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.

4. ASHRAE 135 – BACnet Compliance: Control units shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.

5. LonWorks Compliance: Control units shall use LonTalk protocol and communicate using EIA/CEA 709.1 datalink/physical layer protocol.

C. I/O Interface: Hardwired inputs and outputs may tie into system through controllers. Protect points so that shorting will cause no damage to controllers.

1. Binary Inputs: Allow monitoring of on-off signals without external power.

2. Pulse Accumulation Inputs: Accept up to 10 pulses per second.

3. Analog Inputs: Allow monitoring of low-voltage (0- to 10-V dc), current (4 to 20 mA), or resistance signals.

4. Binary Outputs: Provide on-off or pulsed low-voltage signal, selectable for normally open or normally closed operation with three-position (on-off-auto) override switches and status lights.

5. Analog Outputs: Provide modulating signal, either low voltage (0- to 10-V dc) or current (4 to 20 mA) with status lights, two-position (auto-manual) switch, and manually adjustable potentiometer.

6. Tri-State Outputs: Provide two coordinated binary outputs for control of three-point, floating-type electronic actuators.

7. Universal I/Os: Provide software selectable binary or analog outputs.

D. Power Supplies: Transformers with Class 2 current-limiting type or overcurrent protection; limit connected loads to 80 percent of rated capacity. DC power supply shall match output current and voltage requirements and be full-wave rectifier type with the following:

1. Output ripple of 5.0 mV maximum peak to peak.

2. Combined 1 percent line and load regulation with 100-mic.sec. response time for 50 percent load changes.

3. Built-in overvoltage and overcurrent protection and be able to withstand 150 percent overload for at least 3 seconds without failure.

E. Power Line Filtering: Internal or external transient voltage and surge suppression for workstations or controllers with the following:

1. Minimum dielectric strength of 1000 V.

2. Maximum response time of 10 nanoseconds.

3. Minimum transverse-mode noise attenuation of 65 dB.

4. Minimum common-mode noise attenuation of 150 dB at 40 to 100 Hz.

2.04 SYSTEM SOFTWARE

A. General:

1. Contractor shall provide all software required for efficient operation of all functions required by this specification. Software shall be modular in design for flexibility in expansion or revision of the system. Software shall, as a minimum, include:

   a. Complete database entry.

   b. Configuration of all application programs to provide the sequence of operation indicated.

   c. Complete graphics package, including graphics floor plans and individual graphics, for each system.

   d. Alarm limits and alarm messages for all critical and non-critical alarms.

   e. Configuration of all reports and point summaries indicated.

2. System software shall be complete such that each control loop shall function as specified in the Sequence of Operation.

3. Building control system manufacturer shall be required to write the software program and test the operation of every control loop. A letter certifying that the system is ready for inspection shall be submitted to the engineer prior to the controllers being shipped to the field. The Engineer may at his option visit the contractor's office and witness proper operation of each control loop prior to shipping from the contractor's point of fabrication. The control contractor shall provide a means of simulating every input to the system as a requirement for debugging the software. Prior to shipping of the microprocessor controller, the debugged software shall be transmitted to the owner for approval.

4. After all field connections have been made and control power is available in the control panel, the owner shall be notified and the control system shall be energized. Any required reloading of the software shall be performed and start-up of the mechanical system and building control system shall commence.

5. Building control contractor shall be responsible for all necessary revisions to the software as required to provide a complete and workable system consistent with the letter and intent of the specification. All control performance criteria are specified in the Sequence of Operations section of the specification.

6. After the system has operated properly for 90 days following start-up of the final component of the heating and air conditioning systems, an as-built copy of the software shall be transmitted to the owner for permanent record purposes. Any software upgrading or enhancements to improve the system operation or as required for proper operation of the system during the first year of operation is the responsibility

of the building control system contractor. Any changes to the software shall be immediately transmitted to the Owner.

7. The Building Network Controller shall incorporate the GUI (Graphical User Interface) via a standard web browser. Use of hardware keys or special licenses requirements to access the system with a browser is unacceptable. The building controller will serve up the web pages on a standalone per building application for the intent that if the WAN is not working, an operator can access the system on site via the building internal network using an IP. A server computer will be located at the energy management office to supervise the remote panels and alarm if the communication is lost as well as any control function alarm. This server computer will also be the area of trending archives.

8. Software required to provide the initial operation routines shall not consume more than 70% of the programmable capability of the controller.

9. Software shall be provided in these five categories:

    a. System executive software.

    b. Software for user control over system configuration at the Central Site location, and by Maintenance Personnel in the field.

    c. Facility monitoring functions.

    d. Direct digital control.

    e. Application software.

10. Each category of software shall consist of interactive software modules. Each module shall have an associated priority level and shall execute as determined by the program controller as defined in the real time operating system.

11. Building operator shall be able to communicate and direct all control functions through the use of a 2-button "mouse" operator interface to monitor and control all functions and sequences within the system.

12. Central site shall allow receipt of alarms and messages while in a functional mode other than energy management. I.e. incoming alarms shall be displayed while the operator is in a word processing, spreadsheet or other operating mode. The system must automatically switch from a non- energy management mode, respond to an alarm, and return to the exact position left in the previous functional mode.

13. Central site must be able to generate standard ASCII file formats to allow use with third-party software (**Microsoft Excel**) to generate and store owner-designed reports.

B. Systems Software:

1. Central site shall display graphically, in up to 64 different colors, the following system information:

    a. Floor plan maps shall show heating and cooling zones throughout the buildings in a range of colors which provide a visual display of temperature relative to their respective setpoints. The colors shall be updated dynamically as zones' comfort condition change. Locations of space sensors shall also be shown for each zone. Setpoint adjustment and color band displays shall be provided as specified.

    b. Lighting floor plan maps shall show the status of each individual lighting circuit. When the lights are "on", the area served shall respond in a pre-selected color. When the lights are "off", the area served shall appear gray.

    c. Mechanical system graphics shall show the type of mechanical system components serving any zone through the use of a pictorial representation of components. It shall also provide a current status of all I/O points being controlled and applicable to each piece of equipment including analog readouts in appropriate engineering units at appropriate locations on the graphic representation.

    d. The following information shall be selected from a "pop- up" menu available on various graphics:

        1) Alarms.

        2) Messages.

        3) Module Status.

        4) Programming Parameters.

        5) Quit.

        6) Schedules.

        7) Schedule Graphs.

        8) Schedule Groups.

        9) Setpoints.

        10) Trends.

        11) Utilities.

    e. Programming, scheduling and set-point changes shall be accessible for modification on each menu for the associated equipment. Operator shall be able

to automatically download changes from the central site to the appropriate program for the equipment being controlled. Operator shall be able to upload information from the field modules to the central site.

2. Input Format:

   a. Allowable operators, as defined under user access, shall be able to control system functions by their inputs at an appropriate user terminal. Primary operator interface shall be via two button mouse.

3. Verification of Operator Input:

   a. System shall acknowledge all inputs as functions or commands to be performed. System's handling of operator inputs, such as requests to start a motor, output a log, change a time program, acknowledge an alarm, or do any of the other commands described in this specification, shall be in a similar format.

4. Operator Commands:

   a. All operator commands shall be in graphics data base and menu driven. After the operator selects the desired object item or menu, the system shall display either the status of selected object item or the allowable options available. Upon entry of a command to the point or points desired as described above, the system shall, before performing any command requested and any entered data. System shall include error monitoring software for user's input error.

5. Output Format:

   a. The system shall operate on a System Format basis, regardless of the manner or hardware configuration in which the data is acquired. A "system" shall consist of a logical grouping of data points, related to a piece of mechanical equipment, an energy distribution system, or an architectural area. For example, in some cases, it may be desired to display, as a single system, a space temperature with its associated air handling unit, and in other cases to display all space temperatures on a floor or in a building. The DDC shall allow such determinations to be made without regard to the physical hardware locations of a point or group of points. Likewise, the system shall accommodate future changes of system grouping and operations without field hardware changes.

   b. All displays and logs shall contain a header line indicating date, day-of-week, and time.

   c. All output displays or logs of a point or group of points shall contain, as a minimum, the following information:

      1) Graphic presentation of the System.

      2) User name of point.

3) Point descriptor.

4) Current value/status.

5) Associated engineering units.

6) Alarm description.

d. User names, point descriptors, and engineering units shall be operator definable on a per point basis.

6. Set points:

a. System shall utilize a contiguous band of colors each corresponding to actual zone temperatures relative to the desired heating and cooling setpoints. The ideal temperature shall be shown as a green color band. This color band corresponds to the dead band between the onset of mechanical heating or cooling. Temperatures warmer than ideal shall be shown in orange.

b. Temperatures cooler than ideal shall be blue. All alarm colors shall be in red.

c. System shall be capable of utilizing the mouse operator interface device to change individual zone temperature setpoints. The change shall be accomplished by pointing to a graphic temperature bar and by depressing a button, moving the mouse cursor to an increased or decreased temperature set-point within that zone. System shall also be capable of utilizing the mouse interface device or a conventional keyboard to change a numeric temperature set-point value instead of utilizing the graphic temperature bar. Floor plan graphic shall then be able to change colors on a zone by zone basis to reflect the actual temperature in each zone relative to the changed desired heating or cooling set-point.

d. System shall be capable of globally changing all setpoints. The global change capability shall be accessed via a "pop up menu" called by depressing a button on the mouse.

7. Graphic Structure and Hardware:

a. The intent of the graphics is to ensure the operator is always aware of his position within the system as well as how to logically progress through the graphical hierarchy to select any desired graphic or other source of information. The GUI will be served as a web page and access from any computer without any special software or hardware keys. The building network controller will hold the graphics for standalone operation. A computer on site will not be acceptable to serve the graphics. The sever computer will have the ability to access the system for engineering from the owner, alarming archives and alarms, remote monitoring of the health of the communications to the field

devices and to archive the trend collection data from the building controllers. The web pages will follow a minimum Graphical layout shall be as follows:

1) Main greeting page will have links for all building monitored for quick access.

2) Once a building is selected a picture of the building will be displayed along with a menu of all systems controlled from this section. There will also be links for the floor plans.

3) Once the floor plan has been chosen, the selected graphic page will display the architectural floor plan. This plan will have temperature readings and Setpoints of all VAV's within this floor. There will also be links or button depicting the location and equipment number that is serving that area. This link will hyperlink into the graphic of the AHU. The temperatrre and setpoint reading will hyperlink to the selected VAV grahic for further review. If the floor has too many VAV data readings to display for an easy reading the floor plan may be broken into sections so that the view is easily readable.

4) Graphical VAV – The VAV box will be a graphical representation of a VAV box. The data shown on the box will be as follows:

    a) Box Flow

    b) Box Flow Trend hyperlink

    c) Box Flow Setpoint

    d) Box Flow Trend hyperlink

        i. Box Flow Min Setpoint

        ii. Box Flow Max Setpoint

        iii. Box Flow Reheat Min Setpoint (if applicable)

        iv. Reheat Stage Commands (if applicable)

        v. Supply Air Temperature (with reheat)

        vi. Room Setpoint

        vii. Room Setpoint Trend hyperlink

        viii. Room Temperature

ix. Room Temperature Trend hyperlink

x. Room Humidity (If applicable)

xi. Room Humidity Trend hyperlink

xii. Room Humidity Setpoint (if applicable)

xiii. Room Humidiy Setpoint Trend hyperlink

xiv. All points above to show a different status color if overridden

e) Graphical AHU – The AHU will be a graphical representation of the physical air handling unit specified. The data will be located on the AHU as physically located on the unit. The data on the AHU will be as follows:

i. Schedule for Unit hyperlink – link to the scheduling editor

ii. Schedule for Ventalation hyperlink – link to the scheduling editor.

iii. Occupied/Unoccupied status for each schedule

iv. Fan command

v. Fan status

vi. Fan speed

vii. Fan VFD alarm

viii. Temperature sensors as specified in the control sequence of operation and trending points

ix. All setpoints as specified in the sequence of operation

1. Example – VAV AHU will have a supply air temperature and setpoint

x. Supply air static and trend hyperlink

xi. Supply air static Setpoint and trend hyperlink

xii. Return air damper position

xiii. Outside air damper position

xiv. Outside air flow and trend hyperlink

xv. Outside air flow setpoint and trend hyperlink

xvi. Outside air heater command

xvii. Outside air heater setpoint

xviii. Any misc points needed from a sequence of operation

xix. All points above to show a different status color if overridden

f) Grapical Chiller plant – The plant will be a graphical representation of the physical chiller plant as specified and installed. The data will be located on the graphical screen as physically installed in the plant.

i. All Chiller interface data

ii. Enable/Disable of Chillers and isolation valves

iii. Primary pump command and status

iv. Secondary Pump command, status, speed, and general alarm from the VFD.

v. Flow meters

vi. Temperature sensors

g) Misc. Points and graphical screens

b. Graphical representation of text on these screens – The text blocks will have an opposing color for easier reading

c. Graphical representation of the trends – each point to be trended will have a icon next to the point being trended. This icon will hyperlink to the trending chart builder for the individual trend screen. A trend icon on the main building screen will be a trend chart builder. This trend builder will allow to select multiple trends from a list, pick whether recent trending data or archived (in the server), date range, etc. Then after selection the trend chart builder will compile the data and build the trend for viewing or exporting to a spread sheet. This all happens with a standard web browser.

d. A text block for an overridable point shall be highlighted when a mouse is scrolled over an object. When the text block and or pint is overridden the graphical point will turn to a different color. This allows for easy viewing of which points are overridden on a graphic screen.

8. User Access Restriction. Operator sign-on shall require an assignable password. Passwords shall have six (6) levels of system access **or user defined**:

a. Level 1 - Trainee: The level shall allow readout of data only. System shall display all operation data base.

b. Level 2 - Maintenance 1: This level shall allow all of Level 1 functions plus the changing of all schedules.

c. Level 3 - Maintenance 2: This level shall allow performance of Level 2 functions plus the changing of all set points.

d. Level 4 - Supervisor: This level shall allow performance of Level 3 functions plus the changing of all system parameters.

e. Level 5 - System Programmer: This level shall allow performance of Level 4 functions plus the modifying the system configuration.

f. Level 6 - System Manager: This level shall allow performance of Level 5 functions plus the changing of passwords.

9. Power Failure/Automatic Restart:

a. Power failures shall cause the system to go into an orderly shutdown with no loss of program memory.

b. Upon resumption of power, the system shall automatically restart and printout the time and date of the power failure and restoration at the Central Site. “Restart” program shall automatically restart affected field equipment. Operator shall be able to define an automatic power up time delay for each piece of equipment under control.

c. User Control Over System Configuration:

1) Database Creation and Modification. All changes shall be done utilizing standard procedures and be capable of being done while the system is on-line and operational. The system shall allow changes to be made through the portable operator terminal and form the central site. To aid the user, instructive prompting software shall be provided.

2) System shall permit the operator, with proper password, to perform as a minimum the following:

   a) Add and delete points.

   b) Modify point parameters.

   c) Create and modify control sequences.

   d) Reconfigure application programs.

   e) Add and/or modify graphics.

3) All data points within the database shall be completely accessible as independent or dependent variables for custom programming, calculation, interlocking, or manipulation.

4) Graphics Software:

   a) Graphics software shall permit the easy construction of infinitely variable shapes and sizes through the use of the mouse pointing device.

   b) A selection of 64 colors and various fill textures, line types and text styles shall all be accessible through the use of the mouse interface. The software shall resemble many of the computer aided design programs currently available and allow graphics to be easily moved, edited, added or deleted.

   c) Graphics software shall be fully implemented and operational to accomplish the following:

      i. Create a new graphic picture.

      ii. Modify a portion of a graphic picture.

      iii. Delete a graphic picture, or any portion thereof.

      iv. Call up a graphic picture.

      v. Cancel the display of a graphic picture.

vi. Assign conditions which automatically initiate the display.

vii. Overlay alphanumeric and graphics.

viii. Save the graphic picture.

ix. Display latest process data fully integrated with the graphic display

d. Facility Management Functions:

1) Trend Logging:

a) System shall be able to trend and display either numerically or graphically any analog or digital points in the system.

b) System shall be able to simultaneously graphically display any two trended points within a module function block or any point in the module versus the outside air temperature, enthalpy or relative humidity.

c) Each field module shall be capable of storing the most recent 60 samples for each single trend point or the most recent 30 samples for each of two trended points from one module function block.

d) Each module shall be capable of automatically uploading on a daily basis all accumulated trend data to the central site for permanent storage on hard disk.

2) Run Time:

a) System shall provide run time information for all digital output and input points on command from the operator. Maximum run time limits shall be operator definable and shall be capable of automatically issuing a **visual** when the run time maximum is exceeded. Operator shall be able to reset the run time accumulator.

b) Run time hours and start time date shall be retained in non-volatile module memory.

c) Each module shall be capable of automatically uploading all accumulated data to the central site for permanent storage on hard disk.

3) Alarm Conditions and Maintenance Messages:

a) Central site shall allow receipt of alarms and messages while in a functional mode other than energy management. i.e., Incoming alarms shall be displayed **and generate an audible alarm** while the operator is utilizing another mode such as word processing and allow the operator to automatically return to word processing after the alarm is received.

b) System shall distinguish between alarms and messages with alarms having a higher priority.

c) System shall be capable of calling up to three different remote locations to deliver an alarm or message **through E-Mail, E-Page or alphanumeric page**. Operator shall determine if alarms or messages are to be based on temperature limit, status or off-normal reporting.

d) System shall be capable of printing maintenance messages when run time accumulation maximum limits are exceeded.

e) Text for operator alarm and messages shall be operator definable. System shall be capable of storing at least 100 messages each of any length. Generic messages used for multiple points throughout the system shall only count as one message. In the event the central site is powered down, alarms shall be stored in the modules until the central site is restored.

f) Central site shall be capable of transferring all alarms to hard disk for storage.

4) Reports and Archiving:

a) Field modules shall be capable of calling the central site during off peak phone rate hours to automatically upload all current and accumulated data. This shall be delivered to the central site for printing and/or permanent storage on hard disk. The system shall further be capable of transferring hard disk information onto a CD or USB external drive for remote site storage.

b) System shall be capable of reporting and archiving the following information as a minimum:

1. Outside air temperature history and degree day history.
2. Electric demand and usage history.
3. All trended points.
4. Active six-month rolling trends, not requiring activation by OWNER O&M.

5. All alarms and messages.

6. Equipment runtime information.

a) The system shall also provide the following additional reports for which archiving is not applicable:

1. All points summary.

2. Building operating schedules.

3. Printout of any graphic screen.

b) System shall be capable of providing all points summaries on a hierarchical basis. e.g., only the points associated with a particular graphic shall be selectable and printed. For example, if the operator is viewing an air handling unit (AHU), he may request an all points summary at this level and receive only the points associated with the AHU. If the building is being viewed and an all points summary selected, all building points will be listed. Similarly, the system shall print building operating schedules pertinent to the graphic level being viewed. e.g., if a zone or tenant zone group is being viewed on the graphic display, then the system shall be capable of printing the building operating schedules for the zone or tenant zone group. If the entire building graphic is being viewed, the system shall be capable of printing schedules at the building level. All systems reports shall be capable to being viewed at the operators' terminal and printed at the operator's discretion.

b. Direct Digital Control Software:

1) System shall continuously perform DDC functions at the local DDC controller in a stand-alone mode. The operator shall be able to design and modify the control loops to meet the requirements of the system being operated. Operators shall use system provided displays for tuning of PID loops. These displays shall include the past three input variable values, the set point for the loop as well as the sample interval and the results of the proportional, integral and derivative effects of the final output.

2) Each Controller shall perform the following functions:

a) Identify and report alarm conditions.

b) Execute DDC algorithms.

c) Execute all application programs indicated on the I/O Summary table.

d) Trend and store data.

3) In the event of a Controller failure, all points under its control shall be commanded to the failure mode.

4) All DDC software shall reside in the respective DDC Controller.

c. Application Software:

1) Application software shall be as required to produce the sequence of operation specified.

2.05 ELECTRONIC SENSORS

A. Description: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.

B. Temperature Sensors: 10K resistor style.

1. Accuracy: Plus or minus 0.35 deg F (0.2 deg C) at calibration point.

2. Wire: Twisted, shielded-pair cable.

3. Insertion Elements in Ducts: Single point, 8 inches (200 mm) long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft. (0.84 sq. m).

4. Averaging Elements in Ducts: 36 inches (915 mm) long, flexible; use where prone to temperature stratification or where ducts are larger than 10 sq. ft. (1 sq. m).

5. Insertion Elements for Liquids: Brass or stainless-steel socket with minimum insertion length of 2-1/2 inches (64 mm).

6. Room Sensor Cover Construction: Manufacturer's standard covers.

a. Set-Point Adjustment: Exposed but disable.

b. Set-Point Indication: Exposed.

c. Thermometer: Digital temperature display.

d. Color: Beige

e. Orientation: Vertical.

f. Occupancy Override: Exposed only for office and classrooms.

7. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.

C. Humidity Sensors: Bulk polymer sensor element.

1. Accuracy: 2 percent full range with linear output.

2. Room Sensor Range: 0 to 100 percent relative humidity.

3. Room Sensor Cover Construction: Manufacturer's standard covers.

a. Set-Point Adjustment: Concealed.

b. Set-Point Indication: Exposed.

c. Humidity: Digital humidity display

d. Color: Beige.

e. Orientation: Vertical.

4. Calibration: Single point.

D. Pressure Transmitters/Transducers:

1. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.

a. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.

b. Output: 4 to 20 mA.

c. Building Static-Pressure Range: 0- to 0.25-inch wg.

d. Duct Static-Pressure Range: 0- to 5-inch wg.

2. Water Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure; linear output 4 to 20 mA.

3. Water Differential-Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure and tested to 300-psig; linear output 4 to 20 mA.

4. Differential-Pressure Switch (Air or Water): Snap acting, with pilot-duty rating and with suitable scale range and differential.

5. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; linear output 4 to 20 mA.

E. Room sensor accessories include the following:

1. Guards: Metal wire, tamperproof for sensors located in gymnasiums, locker room, corridors, cafeteria, media center and multipurpose rooms.

2.06 STATUS SENSORS

A. Status Inputs for Fans: Differential-pressure switch with pilot-duty rating and with adjustable range of 0- to 5-inch wg.

B. Status Inputs for Pumps: Differential-pressure switch with pilot-duty rating and with adjustable pressure-differential range of 8 to 60 psig, piped across pump.

C. Current Switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements.

D. Electronic Valve/Damper Position Indicator: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.

E. Water-Flow Switches: Bellows-actuated mercury or snap-acting type with pilot-duty rating, stainless-steel or bronze paddle, with appropriate range and differential adjustment, in NEMA 250, Type 1 enclosure.

2.07 GAS DETECTION EQUIPMENT

A. Carbon Dioxide Sensor and Transmitter: Single detectors using solid-state infrared sensors; suitable over a temperature range of 23 to 130 deg F and calibrated for 0 to 2 percent, with continuous or averaged reading, 4- to 20-mA output;, for wall mounting.

2.08 FLOW MEASURING STATIONS

A. Duct Airflow Station: Thermal Dispersion Technology.

1. Manufacturers:

a. Ebtron.

b. Tekair.

2. Each measuring device shall consist of one or more multi-point measuring probes and single microprocessor-base transmitter. Each transmitter shall have an LCD display capable of displaying airflow and temperature. Airflow shall be field configurable to display as a velocity or volumetric rate. Each transmitter shall operate at 24V.

3. Each sensing point shall independently determine the airflow rate and temperature, which shall be equally weighted and average by the transmitter prior to the output.

Devices, which average multiple non-linear sensing points signals, are not acceptable. Pitot tubes arrays are not acceptable.

4. The operation air flow range shall be 0 – 5,000 FPM.

5. The operation temperature range for the measuring probes shall be -20°F to 160°F.

6. Accuracy: Each independent airflow sensor shall have a laboratory accuracy of ±2% and each independent temperature sensor shall have a laboratory accuracy of ±0.15°F.

7. The transmitter shall be capable of communicating with the host controls using the following interface options:

   a. Linear analog output signal: Field selectable, fuse protected and isolated, 0-10VDC and 4-20mA (4-wire).

   b. LonWorks Free Topology.

B. Pipe Flow Metter: Electromagnetic Flow Meter.

1. Manufacturer:

   a. Onicon.

2. Accuracy: ±1.0% of reading at calibration velocity.

3. Sensing Method: Electromagnetic sensing (no moving parts).

4. Pipe Size Range: 3” through 72”.

5. Supply Voltage: 24 V AC/DC at 250 mA.

6. Liquid Temperature Range: 15°F to 250°F peak.

7. Operating Pressure: 400 psi.

2.09 ENERGY METER

A. BTU Meter.

1. Manufacturer:

   a. Onicon

2. Accuracy: Differential temperature accuracy ±0.15°F.

3. Memory: Non-volatile EEPROM memory retains all parameters and totalized values in the event of power loss.

4. Flow meter: Flow meter by Onicon. Flow meter shall met the requirements of section 2.7.C on these specifications.

5. Temperature sensors: Solid state sensors.

6. Temperature Range: 32°F to 200°F.

7. Display: Alpanumeric LCD display total energy, total flow, energy rate, flow rate, supply temperature and return temperature.

8. Output Signal: LonWorks or BACnet.

2.10 THERMOSTATS

A. Line-Voltage, On-Off Thermostats: Bimetal-actuated, open contact or bellows-actuated, enclosed, snap-switch or equivalent solid-state type, with heat anticipator; listed for electrical rating of 125% of service equipment; with exposed set-point adjustment, 55 to 85 deg F set-point range, and 2 deg F maximum differential.

2.11 ACTUATORS

A. Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.

1. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.

2. Nonspring-Return Motors for Valves Larger Than NPS 2-1/2: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.

3. Spring-Return Motors for Valves Larger Than NPS 2-1/2: Size for running and breakaway torque of 150 in. x lbf.

4. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.

5. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running and breakaway torque of 150 in. x lbf.

B. Electronic Actuators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.

1. Manufacturers:

a. Belimo Aircontrols (USA), Inc.

b. Schneider Electric Dura Drive

2. Valves: Size for torque required for valve close off at maximum pump differential pressure.

3. Dampers: Size for running torque calculated as follows:

a. Parallel-Blade Damper with Edge Seals: 7 inch-lb/sq. ft. of damper.

b. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. of damper.

c. Parallel-Blade Damper without Edge Seals: 4 inch-lb/sq. ft of damper.

d. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. of damper.

e. Dampers with 2- to 3-Inch wg of Pressure Drop or Face Velocities of 1000 to 2500 fpm: Increase running torque by 1.5.

f. Dampers with 3- to 4-Inch wg of Pressure Drop or Face Velocities of 2500 to 3000 fpm: Increase running torque by 2.0.

4. Coupling: V-bolt and V-shaped, toothed cradle.

5. Overload Protection: Electronic overload or digital rotation-sensing circuitry.

6. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on nonspring-return actuators.

7. Power Requirements (Two-Position Spring Return): 24-V ac.

8. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.

9. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.

10. Temperature Rating: Minus 22 to plus 122 deg F.

11. Temperature Rating (Smoke Dampers): Minus 22 to plus 250 deg F.

12. Run Time: 12 seconds open, 5 seconds closed.

2.12 CONTROL VALVES

A. Manufacturers:

1. Belimo.

2. Schneider Electric

B. Control Valves: Factory fabricated, of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated.

C. Butterfly Valves: 200-psig, 150-psig maximum pressure differential, ASTM A 126 cast-iron or ASTM A 536 ductile-iron body and bonnet, extended neck, stainless-steel stem, field-replaceable EPDM or Buna N sleeve and stem seals.

1. Body Style: Wafer or Grooved.

2. Disc Type: Nickel-plated ductile iron.

3. Sizing: 1-psig maximum pressure drop at design flow rate.

D. Terminal Unit Control Valves: Bronze body, bronze trim, two or three ports as indicated, replaceable plugs and seats, and union and threaded ends.

1. Rating: Class 125 for service at 125 psig and 250 deg F operating conditions.

2. Sizing: 3-psig maximum pressure drop at design flow rate, to close against pump shutoff head.

3. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.

2.13 DAMPERS

A. Dampers: AMCA-rated, parallel-blade for return air damper and opposed blade for outside air and relief air design; 0.108-inch- minimum thick, galvanized-steel or 0.125-inch- minimum thick, extruded-aluminum frames with holes for duct mounting; damper blades shall not be less than 0.064-inch- thick galvanized steel with maximum blade width of 8 inches and length of 48 inches.

1. Secure blades to 1/2-inch- diameter, zinc-plated axles using zinc-plated hardware, with oil-impregnated sintered bronze blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.

2. Operating Temperature Range: From minus 40 to plus 200 deg F.

3. Edge Seals, Standard Pressure Applications: Closed-cell neoprene.

4. Edge Seals, Low-Leakage Applications: Use replaceable rubber blade seals and spring-loaded stainless-steel side seals, rated for leakage at less than 10 cfm per sq. ft. of damper area, at differential pressure of 4-inch wg when damper is held by torque of 50 in. x lbf; when tested according to AMCA 500D.

2.14 CONTROL CABLE

A. Electronic and fiber-optic cables for control wiring are specified in Division 16 Section "Data Communications Integrations."

PART 3 – EXECUTION

3.01 EXAMINATION

A. Verify that power supply is available to control units and operator workstation.

3.02 INSTALLATION

A. Install software in control units and operator workstation(s). Implement all features of programs to specified requirements and as appropriate to sequence of operation.

B. Connect and configure equipment and software to achieve sequence of operation specified.

C. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches above the floor.

1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.

D. Install automatic dampers according to Division 15 Section "Air Duct Accessories."

E. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.

F. Install labels and nameplates to identify control components according to Division 15 Section "Identification for HVAC Piping and Equipment."

G. Install duct volume-control dampers according to Division 15 Sections specifying air ducts.

H. Install electronic and fiber-optic cables according to Division 16 Section "Communications Horizontal Cabling."

3.03 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. All control cabling shall be installed in conduit. No plenum cable allowed.

1. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.

2. Install exposed cable in raceway.

3. Install concealed cable in raceway.

4. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.

5. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.

6. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.

7. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.

B. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

C. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

3.04 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.

2. Test and adjust controls and safeties.

3. Test calibration of electronic controllers by disconnecting input sensors and stimulating operation with compatible signal generator.

4. Test each point through its full operating range to verify that safety and operating control set points are as required.

5. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.

6. Test each system for compliance with sequence of operation.

7. Test software and hardware interlocks.

C. DDC Verification:

1. Verify that instruments are installed before calibration, testing, and loop or leak checks.

2. Check instruments for proper location and accessibility.

3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.

4. Check instrument tubing for proper fittings, slope, material, and support.

5. Check installation of air supply for each instrument.

6. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.

7. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.

8. Check temperature instruments and material and length of sensing elements.

9. Check control valves. Verify that they are in correct direction.

10. Check DDC system as follows:

    a. Verify that DDC controller power supply is from emergency power supply, if applicable.

    b. Verify that wires at control panels are tagged with their service designation and approved tagging system.

    c. Verify that spare I/O capacity has been provided.

    d. Verify that DDC controllers are protected from power supply surges.

D. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.05 ADJUSTING

A. Calibrating and Adjusting:

1. Calibrate instruments.

2. Make three-point calibration test for both linearity and accuracy for each analog instrument.

3. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.

4. Control System Inputs and Outputs:

a. Check analog inputs at 0, 50, and 100 percent of span.

b. Check analog outputs using milliampere meter at 0, 50, and 100 percent output.

c. Check digital inputs using jumper wire.

d. Check digital outputs using ohmmeter to test for contact making or breaking.

e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.

5. Flow:

a. Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 50, 90, and 100 percent of span.

b. Manually operate flow switches to verify that they make or break contact.

6. Pressure:

a. Calibrate pressure transmitters at 0, 50, and 100 percent of span.

b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.

7. Temperature:

a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.

b. Calibrate temperature switches to make or break contacts.

8. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.

9. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.

10. Provide diagnostic and test instruments for calibration and adjustment of system.

11. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.

B. Adjust initial temperature and humidity set points.

C. 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 three visits to Project during other than normal occupancy hours for this purpose.

3.06 DEMONSTRATION AND SUPPORT

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls. Refer to Division 01 Section "Demonstration and Training."

B. Engage a factory-authorized service representative to perform commissioning functional performance tests through the BAS operator’s workstation for CxA witnessing. Provide a minimum of 40 man hours.

END OF SECTION

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SECTION 15950

TESTING, ADJUSTING, AND BALANCING

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section includes TAB to produce design objectives for the following:

1. Air Systems:

a. Constant-volume air systems.

2. HVAC equipment quantitative-performance settings.

3. Verifying that automatic control devices are functioning properly.

4. Reporting results of activities and procedures specified in this Section.

1.03 DEFINITIONS

A. Adjust: To regulate fluid flow rate and air patterns at the terminal equipment, such as to reduce fan speed or adjust a damper.

B. Balance: To proportion flows within the distribution system, including submains, branches, and terminals, according to indicated quantities.

C. Barrier or Boundary: Construction, either vertical or horizontal, such as walls, floors, and ceilings that are designed and constructed to restrict the movement of airflow, smoke, odors, and other pollutants.

D. Draft: A current of air, when referring to localized effect caused by one or more factors of high air velocity, low ambient temperature, or direction of airflow, whereby more heat is withdrawn from a person's skin than is normally dissipated.

E. Procedure: An approach to and execution of a sequence of work operations to yield repeatable results.

F. Report Forms: Test data sheets for recording test data in logical order.

G. Static Head: The pressure due to the weight of the fluid above the point of measurement. In a closed system, static head is equal on both sides of the pump.

H. Suction Head: The height of fluid surface above the centerline of the pump on the suction side.

I. System Effect: A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.

J. System Effect Factors: Allowances used to calculate a reduction of the performance ratings of a fan when installed under conditions different from those presented when the fan was performance tested.

K. TAB: Testing, adjusting, and balancing.

L. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.

M. Test: A procedure to determine quantitative performance of systems or equipment.

N. Testing, Adjusting, and Balancing (TAB) Firm: The entity responsible for performing and reporting TAB procedures.

1.04 SUBMITTALS

A. Qualification Data: Within 30 days from Contractor's Notice to Proceed, submit 2 copies of evidence that TAB firm and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Contract Documents Examination Report: Within 45 days from Contractor's Notice to Proceed, submit **6** copies of the Contract Documents review report as specified in Part 3.

C. Strategies and Procedures Plan: Within 60 days from Contractor's Notice to Proceed, submit 2 copies of TAB strategies and step-by-step procedures as specified in Part 3 "Preparation" Article. Include a complete set of report forms intended for use on this Project.

D. Certified TAB Reports: Submit two copies of reports prepared, as specified in this Section, on approved forms certified by TAB firm.

E. Sample Report Forms: Submit two sets of sample TAB report forms.

F. Warranties specified in this Section.

1.05 QUALITY ASSURANCE

A. TAB Firm Qualifications: Engage a TAB firm certified by either AABC or NEBB.

B. Certification of TAB Reports: Certify TAB field data reports. This certification includes the following:

1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.

2. Certify that TAB team complied with approved TAB plan and the procedures specified and referenced in this Specification.

C. TAB Report Forms: Use standard forms from AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems."

D. Instrumentation Type, Quantity, and Accuracy: As described in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems."

E. Instrumentation Calibration: Calibrate instruments at least every six months or more frequently if required by instrument manufacturer.

1. Keep an updated record of instrument calibration that indicates date of calibration and the name of party performing instrument calibration.

1.06 PROJECT CONDITIONS

A. Owner Occupancy: Owner will not occupy the building during entire TAB period. T&B reports shall be finalized and approved prior to owner occupancy.

B. T&B firm shall be independent from the mechanical contractor.

1.07 COORDINATION

A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist TAB activities.

B. Notice: Provide seven days' advance notice for each test. Include scheduled test dates and times.

C. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

1.08 WARRANTY

A. National Project Performance Guarantee: Provide a guarantee on AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems", or NEBB’s Quality Assurance Program, forms stating that AABC, or NEBB, forms stating that AABC will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents. Guarantee includes the following provisions:

1. The certified TAB firm has tested and balanced systems according to the Contract Documents.

2. Systems are balanced to optimum performance capabilities within design and installation limits.

PART 2 – PRODUCTS (NOT APPLICABLE)

PART 3 – EXECUTION

3.01 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.

1. Contract Documents are defined in the General and Supplementary Conditions of Contract.

2. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.

B. Examine approved submittal data of HVAC systems and equipment.

C. Examine Project Record Documents described in Division 1 Section "Project Record Documents."

D. Examine design data, including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine equipment performance data including fan and pump curves. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system. Calculate system effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," Sections 7 through 10; or in SMACNA's "HVAC Systems--Duct Design," Sections 5 and 6. Compare this data with the design data and installed conditions.

F. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Sections have been performed.

G. Examine system and equipment test reports.

H. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and that their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.

I. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.

J. Examine HVAC equipment to ensure that clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

K. Examine terminal units, such as variable-air-volume boxes, to verify that they are accessible and their controls are connected and functioning.

L. Examine plenum ceilings used for supply air to verify that they are airtight. Verify that pipe penetrations and other holes are sealed.

M. Examine strainers for clean screens and proper perforations.

N. Examine equipment for installation and for properly operating safety interlocks and controls.

O. Examine automatic temperature system components to verify the following:

1. Dampers, valves, and other controlled devices are operated by the intended controller.

2. Dampers and valves are in the position indicated by the controller.

3. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multizone units, mixing boxes, and variable-air-volume terminals.

4. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.

5. Sensors are located to sense only the intended conditions.

6. Sequence of operation for control modes is according to the Contract Documents.

7. Controller set points are set at indicated values.

8. Interlocked systems are operating.

9. Changeover from heating to cooling mode occurs according to indicated values.

P. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.02 PREPARATION

A. Prepare a TAB plan that includes strategies and step-by-step procedures.

B. Complete system readiness checks and prepare system readiness reports. Verify the following:

1. Automatic temperature-control systems are operational.

2. Equipment and duct access doors are securely closed.

3. Balance, smoke, and fire dampers are open.

4. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.

5. Windows and doors can be closed so indicated conditions for system operations can be met.

6. Permanent electrical power wiring is complete.

3.03 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" or NEBB's "Procedural Standards for Testing Adjusting and Balancing of Environmental Systems" and this Section.

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to insulation Specifications for this Project.

C. Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.04 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

C. For variable-air-volume systems, develop a plan to simulate diversity.

D. Determine the best locations in main and branch ducts for accurate duct airflow measurements.

E. Check airflow patterns from the outside-air louvers and dampers and the return- and exhaust-air dampers, through the supply-fan discharge and mixing dampers.

F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

G. Verify that motor starters are equipped with properly sized thermal protection.

H. Check dampers for proper position to achieve desired airflow path.

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.

K. Check for proper sealing of air-handling unit components.

L. Check for proper sealing of air duct system.

3.05 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure fan static pressures to determine actual static pressure as follows:

a. Measure outlet static pressure as far downstream from the fan as practicable and upstream from restrictions in ducts such as elbows and transitions.

b. Measure static pressure directly at the fan outlet or through the flexible connection.

c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from flexible connection and downstream from duct restrictions.

d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.

2. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.

   a. Simulate dirty filter operation and record the point at which maintenance personnel must change filters.

3. Measure static pressures entering and leaving other devices such as sound traps, heat recovery equipment, and air washers, under final balanced conditions.

4. Compare design data with installed conditions to determine variations in design static pressures versus actual static pressures. Compare actual system effect factors with calculated system effect factors to identify where variations occur. Recommend corrective action to align design and actual conditions.

5. Obtain approval from Architect for adjustment of fan speed higher or lower than indicated speed. Make required adjustments to pulley sizes, motor sizes, and electrical connections to accommodate fan-speed changes.

6. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full cooling, full heating, economizer, and any other operating modes to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.

1. Measure static pressure at a point downstream from the balancing damper and adjust volume dampers until the proper static pressure is achieved.

   a. Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.

2. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.

C. Measure terminal outlets and inlets without making adjustments.

1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.

D. Adjust terminal outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using volume dampers rather than extractors and the dampers at air terminals.

1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.

2. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.06 PROCEDURES FOR MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer, model, and serial numbers.

2. Motor horsepower rating.

3. Motor rpm.

4. Efficiency rating.

5. Nameplate and measured voltage, each phase.

6. Nameplate and measured amperage, each phase.

7. Starter thermal-protection-element rating.

B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass for the controller to prove proper operation. Record observations, including controller manufacturer, model and serial numbers, and nameplate data.

3.07 PROCEDURES FOR CONDENSING UNITS

A. Verify proper rotation of fans.

B. Measure entering- and leaving-air temperatures.

C. Record compressor data.

3.08 PROCEDURES FOR TEMPERATURE MEASUREMENTS

A. During TAB, report the need for adjustment in temperature regulation within the automatic temperature-control system.

B. Measure indoor wet- and dry-bulb temperatures every other hour for a period of two successive eight-hour days, in each separately controlled zone, to prove correctness of final temperature settings. Measure when the building or zone is occupied.

C. Measure outside-air, wet- and dry-bulb temperatures.

3.09 TEMPERATURE-CONTROL VERIFICATION

A. Verify that controllers are calibrated and commissioned.

B. Check transmitter and controller locations and note conditions that would adversely affect control functions.

C. Record controller settings and note variances between set points and actual measurements.

D. Check the operation of limiting controllers (i.e., high- and low-temperature controllers).

E. Check free travel and proper operation of control devices such as damper and valve operators.

F. Check the sequence of operation of control devices. Note air pressures and device positions and correlate with airflow and water flow measurements. Note the speed of response to input changes.

G. Check the interaction of electrically operated switch transducers.

H. Check the interaction of interlock and lockout systems.

I. Check main control supply-air pressure and observe compressor and dryer operations.

J. Record voltages of power supply and controller output. Determine whether the system operates on a grounded or nongrounded power supply.

K. Note operation of electric actuators using spring return for proper fail-safe operations.

3.10 TOLERANCES

A. Set HVAC system airflow and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.

2. Air Outlets and Inlets: Plus or minus10 percent.

3.11 REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for sys-

tems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

B. Status Reports: As Work progresses, prepare reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.12 FINAL REPORT

A. General: Typewritten, or computer printout in letter-quality font, on standard bond paper, in three-ring binder, tabulated and divided into sections by tested and balanced systems.

B. Include a certification sheet in front of binder signed and sealed by the certified testing and balancing engineer.

1. Include a list of instruments used for procedures, along with proof of calibration.

C. Final Report Contents: In addition to certified field report data, include the following:

1. Fan curves.

2. Manufacturers' test data.

3. Field test reports prepared by system and equipment installers.

4. Other information relative to equipment performance, but do not include Shop Drawings and Product Data.

D. General Report Data: In addition to form titles and entries, include the following data in the final report, as applicable:

1. Title page.

2. Name and address of TAB firm.

3. Project name.

4. Project location.

5. Architect's name and address.

6. Engineer's name and address.

7. Contractor's name and address.

8. Report date.

9. Signature of TAB firm who certifies the report.

10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.

11. Summary of contents including the following:

    a. Indicated versus final performance.

    b. Notable characteristics of systems.

    c. Description of system operation sequence if it varies from the Contract Documents.

12. Nomenclature sheets for each item of equipment.

13. Data for terminal units, including manufacturer, type size, and fittings.

14. Notes to explain why certain final data in the body of reports varies from indicated values.

15. Test conditions for fan performance forms including the following:

    a. Settings for outside-, return-, and exhaust-air dampers.

    b. Conditions of filters.

    c. Cooling coil, wet- and dry-bulb conditions.

    d. Face and bypass damper settings at coils.

    e. Fan drive settings including settings and percentage of maximum pitch diameter.

    f. Inlet vane settings for variable-air-volume systems.

    g. Settings for supply-air, static-pressure controller.

    h. Other system operating conditions that affect performance.

E. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outside, supply, return, and exhaust airflows.

2. Duct, outlet, and inlet sizes.

3. Pipe and valve sizes and locations.

4. Balancing stations.

5. Position of balancing devices.

F. Air-Handling Unit Test Reports: For air-handling units with coils, include the following:

1. Unit Data: Include the following:

a. Unit identification.

b. Location.

c. Make and type.

d. Model number and unit size.

e. Manufacturer's serial number.

f. Unit arrangement and class.

g. Discharge arrangement.

h. Sheave make, size in inches (mm), and bore.

i. Sheave dimensions, center-to-center, and amount of adjustments in inches (mm).

j. Number of belts, make, and size.

k. Number of filters, type, and size.

2. Motor Data:

a. 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 (mm), and bore.

f. Sheave dimensions, center-to-center, and amount of adjustments in inches (mm).

3. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm (L/s).

b. Total system static pressure in inches wg (Pa).

c. Fan rpm.

d. Discharge static pressure in inches wg (Pa).

e. Filter static-pressure differential in inches wg (Pa).

f. Preheat coil static-pressure differential in inches wg (Pa).

g. Cooling coil static-pressure differential in inches wg (Pa).

h. Heating coil static-pressure differential in inches wg (Pa).

i. Outside airflow in cfm (L/s).

j. Return airflow in cfm (L/s).

k. Outside-air damper position.

l. Return-air damper position.

m. Vortex damper position.

G. Apparatus-Coil Test Reports:

1. Coil Data:

a. System identification.

b. Location.

c. Coil type.

d. Number of rows.

e. Fin spacing in fins per inch (mm) o.c.

f. Make and model number.

g. Face area in sq. ft. (sq. m).

h. Tube size in NPS (DN).

i. Tube and fin materials.

j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm (L/s).

b. Average face velocity in fpm (m/s).

c. Air pressure drop in inches wg (Pa).

d. Outside-air, wet- and dry-bulb temperatures in deg F (deg C).

e. Return-air, wet- and dry-bulb temperatures in deg F (deg C).

f. Entering-air, wet- and dry-bulb temperatures in deg F (deg C).

g. Leaving-air, wet- and dry-bulb temperatures in deg F (deg C).

h. Refrigerant expansion valve and refrigerant types.

i. Refrigerant suction pressure in psig (kPa).

j. Refrigerant suction temperature in deg F (deg C).

H. Electric-Coil Test Reports: For electric furnaces, duct coils, and electric coils installed in central-station air-handling units, include the following:

1. Unit Data:

a. System identification.

b. Location.

c. Coil identification.

d. Capacity in Btuh (kW).

e. Number of stages.

f. Connected volts, phase, and hertz.

g. Rated amperage.

h. Airflow rate in cfm (L/s).

i. Face area in sq. ft. (sq. m).

j. Minimum face velocity in fpm (m/s).

2. Test Data (Indicated and Actual Values):

a. Heat output in Btuh (kW).

b. Airflow rate in cfm (L/s).

c. Air velocity in fpm (m/s).

d. Entering-air temperature in deg F (deg C).

e. Leaving-air temperature in deg F (deg C).

f. Voltage at each connection.

g. Amperage for each phase.

I. 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. Arrangement and class.

g. Sheave make, size in inches (mm), and bore.

h. Sheave dimensions, center-to-center, and amount of adjustments in inches (mm).

2. Motor Data:

a. 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 (mm), and bore.

f. Sheave dimensions, center-to-center, and amount of adjustments in inches (mm).

g. Number of belts, make, and size.

3. Test Data (Indicated and Actual Values):

    a. Total airflow rate in cfm (L/s).

    b. Total system static pressure in inches wg (Pa).

    c. Fan rpm.

    d. Discharge static pressure in inches wg (Pa).

    e. Suction static pressure in inches wg (Pa).

J. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:

    a. System and air-handling unit number.

    b. Location and zone.

    c. Traverse air temperature in deg F (deg C).

    d. Duct static pressure in inches wg (Pa).

    e. Duct size in inches (mm).

    f. Duct area in sq. ft. (sq. m).

    g. Indicated airflow rate in cfm (L/s).

    h. Indicated velocity in fpm (m/s).

    i. Actual airflow rate in cfm (L/s).

    j. Actual average velocity in fpm (m/s).

    k. Barometric pressure in psig (Pa).

K. Instrument Calibration Reports:

1. Report Data:

    a. Instrument type and make.

    b. Serial number.

    c. Application.

d. Dates of use.

e. Dates of calibration.

3.13 INSPECTIONS

A. Initial Inspection:

1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the Final Report.

2. Randomly check the following for each system:

a. Measure airflow of at least 10 percent of air outlets.

b. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.

c. Measure sound levels at two locations.

d. Measure space pressure of at least 10 percent of locations.

e. Verify that balancing devices are marked with final balance position.

f. Note deviations to the Contract Documents in the Final Report.

B. Final Inspection:

1. After initial inspection is complete and evidence by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by Architect.

2. TAB firm test and balance engineer shall conduct the inspection in the presence of Owner.

3. Architect shall randomly select measurements documented in the final report to be rechecked. The rechecking shall be limited to either 10 percent of the total measurements recorded, or the extent of measurements that can be accomplished in a normal 8-hour business day.

4. If the rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."

5. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

6. TAB firm shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes and resubmit the final report.

7. Request a second final inspection. If the second final inspection also fails, Owner shall contract the services of another TAB firm to complete the testing and balancing in accordance with the Contract Documents and deduct the cost of the services from the final payment.

3.14 ADDITIONAL TESTS

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

B. Provide a minimum of 1 man-day of time for Cx verification of readings indicated in the final report.

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

END OF SECTION

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Section 16010

ELECTRICAL – GENERAL PROVISIONS

PART 1 - GENERAL

1.1 SCOPE

A. Furnish all labor, materials, equipment and incidentals required for a complete electrical system hereinafter specified and shown on the Contract Drawings.

B. The work, apparatus and materials which shall be furnished under these Specifications and accompanying Contract Drawings shall include all items listed hereinafter and/or shown on the Contract Drawings. Certain equipment will be furnished as specified in other sections of these Specifications which will require wiring thereto and/or complete installation as indicated. All materials necessary for the complete installation shall be furnished and installed by the Contractor to provide complete power, lighting, communication systems, field instrumentation wiring, and control systems as indicated on the Contract Drawings and/or as specified herein.

C. The Contractor shall furnish and install the necessary cables, transformers, protective devices, conductors, exterior electrical system, etc., to serve motor loads, lighting loads and miscellaneous electrical loads as indicated on the Contract Drawings and/or as specified hereinafter.

D. All electronics, as part of electrical equipment, shall meet the atmospheric conditions of the space the equipment is installed in. All electronics that are not installed in a conditioned environment shall be fungus resistant.

E. All electrical equipment shall be rated for the conditions of the physical installation. All electrical rooms are designated as corrosive areas and the appropriate raceway, equipment and appurtenances shall be installed. All indoor chemical and process equipment areas shall be considered wet locations.

F. The work shall include testing of all equipment and wiring at the completion of the work and making any minor connection changes or adjustments necessary for the proper functioning of the system and equipment. All workmanship shall be of the highest quality; substandard work will be rejected.

G. Mount and wire instruments furnished under other Divisions of these Specifications.

H. Make all field connections to instrument panels and other control panels furnished under other Divisions of these Specifications.

I. For instrumentation, the Contractor shall furnish and install all conduit, wire and interconnections between primary elements, transmitters, local indicators and receivers.

J. Furnish necessary devices and make connections to provide power to equipment. This will require appropriate receptacles in some cases and direct wiring in other cases, depending upon equipment furnished.

K. Install and wire all thermostats and other devices furnished under other Divisions of this Specification.
L. All planned power interruptions shall be at the City's convenience. Each interruption shall have prior approval.
M. It is the intent of these Specifications that the electrical system shall be suitable in every way for the service required. All material and all work, which may be reasonably implied as being incidental to the work of this Section, shall be furnished at no extra cost.
N. Where the City's drawings "Low Voltage (LV) Standards" for facility projects and "Lift Stations (LS) Standards for Lift Stations is referenced in these Division 16 specifications, refer to the electrical and instrumentation drawings for these requirements. Should there be any conflicts, the more stringent requirement shall apply.

1.2 INSPECTION OF THE SITE AND EXISTING CONDITIONS

A. The Electrical Drawings were developed from past record drawings and information supplied by the City. The Contractor shall verify all scaled dimensions prior to submitting bids.
B. Each Bidder or his authorized representative shall, before preparing his proposal, visit all areas of the facilities and structures in which work under this division is to be performed and inspect carefully the present installation. The submission of the proposal by this Bidder shall be considered evidence that he or his representative has visited the area and noted the locations and conditions under which the work will be performed and that he takes full responsibility for a complete knowledge of all factors governing his work. No subsequent increase in Contract cost will be allowed for additional work required because of the Contractor's failure to fulfill this requirement.
C. Carry out any work involving the shutdown of the existing services to any piece of equipment now functioning in existing areas at such time as to provide the least amount of inconvenience to the City. Do such work when directed by the Engineer.
D. Contractor shall protect all existing underground utilities during construction. The Contractor to pay for all required repairs without increase in Contract cost, should damage to underground utilities occur during construction.

1.3 CONTRACTOR QUALIFICATIONS

A. The Contractor shall be experienced in this type of work; "experienced" means having successfully completed a minimum of the following:
    1. Seven (7) verifiable years in the performance of work on projects with similar skill set requirements including but not limited to Medium Voltage Distribution Apparatus and cable systems;
    2. Minimum of two (2) years of which have taken place within the past sixty (60) months;
    3. A minimum of five (5) projects similar in size and scope to this Project;

1.4 SERVICE AND METERING

A. Permanent electrical service is provided by OUC.

1.5 COORDINATION

A. The Contractor shall coordinate, in writing with complete written documentation, with the other trade contractors to deliver a seamless integrated coherent system.

B. The Contractor shall coordinate with a minimum of a two-week notice, in writing with complete written documentation, with the City to minimize any interruption to existing production and schedules. All planned power interruptions, testing and training schedules shall be at the City's convenience and approved by City.

1.6 CODES, INSPECTION AND FEES

A. All material and installation shall be in accordance with the latest edition of the National Electrical Code® (NEC®) and all applicable national, local and state codes.

B. The Contractor shall pay all fees required for permits and inspections including any charges associated with the service modifications.

1.7 QUALITY CONTROL

A. The basis of design is based on the Manufacturers listed in the specifications and the Contract Drawings. Acceptance of alternate Manufacturers shall be made at the Engineer's and City's discretion. Manufacturers seeking Engineer approval shall submit a complete qualifications package. The package shall be submitted a minimum of ten (10) days prior to the bid date for the Engineer's review and approval.

B. Failure to submit a request for an alternate as per the Contract Documents shall deem the Manufacturer as "Not Equal" and will not be reviewed during the shop drawing submittal phase.

C. The request for an alternate package shall include the following:

1. A listing of experience in systems of similar size and complexity. Provide references for a minimum of five (5) completed water and/or wastewater projects furnished within the last four (4) years. For each identify the following:
    a. Project name;
    b. Project dollar value;
    c. General Contractor, with contact name and telephone number;
    d. Engineer of Record (EOR) with contact name and telephone number;
    e. City, with contact name and telephone number;
2. Submit evidence of UL Listed factory and/or facility;
3. Have an established service facility from which qualified technical service personnel and parts may be dispatched upon call. Such a service facility shall be no more than six (6) hours travel time from the jobsite. Identify the location of said facility;
4. A complete package including equipment data sheets, layout information, UL Listing and proposed accessories including but not limited to the 480-Volt switchgear, Motor Control Centers, Profibus Devices, control panels and communication devices.

5. A complete listing of any and all exceptions taken by the alternate Manufacturer to the contract documents with the proposed alternatives required to meet the intent of the specifications. Failure to submit proposed alternatives shall deem the package as non-compliant and therefore the alternate Manufacturer will be deemed “Not Equal”.

D. All equipment furnished by the Manufacturer shall be of the latest and most recent design and shall have overall accuracy as guaranteed by the Manufacturer.

E. Materials and equipment used shall be UL Listed wherever such approved equipment and materials are available.

F. Component equipment shall be as supplied by one of the Manufacturers named or approved equal. The design of the control system is based on the named Manufacturer's equipment used in the design, if there is a difference.

G. To facilitate the City's operation and maintenance, products shall be of the same major Manufacturer, with panel mounted devices of the same type and model as far as possible.

H. In order to insure the interchangeability of parts and the maintenance of quality, strict compliance with the above requirements shall be maintained.

I. The Manufacturer shall designate a single point of contact for interface with the Engineer on this project. The Engineer reserves the sole right to approve or reject this point of contact.

J. The Manufacturer shall provide experienced personnel on-site to coordinate and/or perform installation, termination, and adjustment; on-site testing; City training; and startup assistance for the electrical system.

1.8 TESTS

A. Test all systems and repair or replace all defective work. Make all necessary adjustments to the systems and instruct the City's personnel in the proper operation of the systems.

B. The following minimum tests and checks shall be made prior to the energizing of electrical equipment and cabling. Testing shall be by an independent NETA certified testing firm, and a certified test report shall be submitted stating that the equipment meets and operates in accordance with the Manufacturer's and job specifications, and that equipment and installation conforms to all applicable Standards, Contract Drawings and Specifications:

1. Testing and setting of protective relays for calibration and proper operation;
2. Mechanical inspection of all 480-Volt circuit breakers 100-amps and larger to assure proper operation;
3. Motors: Megger to ground each motor winding; Record date, motor temperature, terminal, reading and operator and have City representative sign off on each reading;
4. 480-Volt Conductors: Megger to ground prior to termination all conductors not used for service conductors. Record the date, conductor, reading and operator and have City representative sign off

on each reading. Submit report in both hard copy and electronic format (PDF) for final approval.

5. Service Conductors: Megger to ground prior to termination in the presence of the Engineer or his representative all 600-volt service conductors. Record date, conductor, reading, operator, and have the City representative sign off on each reading. Submit report in both hard copy and electronic format (PDF) for final approval.
6. 480-Volt Power Panelboards/Switchboards: After installing, with circuit breakers closed, but prior to terminating any conductors, megger each phase to phase and phase to ground. Record the date, test (i.e. A/B or A/G), reading and operator and have City's representative sign off on each reading. Submit report in both hard copy and electronic format (PDF) for final approval.
7. Connections & Terminations: Torque to Manufacturer's values in the presence of the Engineer or his representative. Record the date, conductor, torque, and operator and have the Engineer sign off on each reading. Submit report in both hard copy and electronic format (PDF) for final approval.
8. Hot Spot Testing: Perform infrared hot spot inspection of all 480-Volt and 13.2-kV terminations, and associated equipment as soon as determined by the Engineer that representative loads are present. Record the date, gear conditions found, operator and have the City's representative who must be present for the inspection sign off in each instance. Submit report in both hard copy and electronic format (PDF) for final approval.
9. Miscellaneous:
    a. Meggering must be done at 1000VDC for one-minute. The ground plane used must be the one established at the main source of energy for conductors. The motor frame may be used for the ground plane for motors.
    b. In the course of construction, it will become necessary to temporarily energize some systems for testing. Confirm that any motor has been meggered prior to connection and testing. Do not leave any motor or system unattended and energized without written authorization.
    c. An unsuccessful test will be one in which any one of the three megger readings differs from another by more than 25%. Engineer shall determine if cables and/or equipment bussing shall be replaced.

1.9 SLEEVES AND FORMS FOR OPENINGS

A. Provide and place all sleeves for conduits penetrating floors, walls, partitions, etc. Locate all necessary slots for electrical work and form before concrete is poured.

1.10 CUTTING AND PATCHING

A. All cutting, and patching shall be done in a thoroughly workmanlike manner.

1.11 INTERPRETATION OF CONTRACT DRAWINGS

A. The Contract Drawings are not intended to show exact locations of conduit runs.
B. All three-phase circuits shall be run in separate conduits unless otherwise shown on the Contract Drawings.
C. Unless otherwise approved by the Engineer, conduit shown exposed shall be installed exposed; conduit shown concealed shall be installed concealed.
D. Where circuits are shown as "home-runs" all necessary fittings and boxes shall be provided for a complete raceway installation.
E. No shared or common neutrals shall be installed.
F. The Contractor shall harmonize the work of the different trades so that interferences between conduits, piping, equipment, architectural and structural work will be avoided. All necessary offsets shall be furnished so as to take up a minimum space and all such offsets, fittings, etc., required to accomplish this shall be furnished and installed by the Contractor without additional expense to the City. In case interference develops, the City's authorized representative is to decide which equipment, piping, etc., must be relocated, regardless which was installed first.
G. Verify with the Engineer the exact locations and mounting heights of lighting fixtures, switches and receptacles prior to installation.
H. The locations of equipment, fixtures, outlets, and similar devices shown on the Drawings are approximate only. Exact locations shall be as approved by the Engineer during construction. Obtain in the field all information relevant to the placing of electrical work and in case of any interference with other work, proceed as directed by the Engineer and furnish all labor and materials necessary to complete the work in an approved manner.
I. Surface mounted panel boxes, junction boxes, conduit, etc., shall be supported by spacers to provide a clearance between wall and equipment.
J. Circuit layouts shown are not intended to show the number of fittings, or other installation details. Furnish all labor and materials necessary to install and place in satisfactory operation all power, lighting, and other electrical systems shown. Additional circuits shall be installed wherever needed to conform to the specific requirements of the equipment.
K. The ratings of motors and other electrically operated devices together with the size shown for their branch circuit conductors and conduits are approximate only and are indicative of the probable power requirements insofar as they can determine in advance of the purchase of equipment.
L. All connections to equipment shall be made as shown, specified, and directed and in accordance with the Manufacturer's approved shop drawings, regardless of the number of conductors shown on the Contract Drawings.

1.12 SIZE OF EQUIPMENT

A. Investigate each space in the building where equipment must pass to reach its final location. If necessary, the Manufacturer shall be required to ship his material in sections, sized to permit passing through such restricted areas in the building.

B. The equipment shall be kept upright at all times. When equipment has to be tilted for ease of passage through restricted areas during transportation, the Manufacturer shall be required to brace the equipment suitably, to ensure that the tilting does not impair the functional integrity of the equipment.

1.13 RECORD DRAWINGS

A. Requirements for record drawings are specified in Section 01050.

1.14 OPERATIONS AND MAINTENANCE (O&M) MANUALS

A. Requirements for O&M manuals are specified in Section 01730.The manuals shall be prepared specifically for this installation and shall include catalog data sheets, drawings, equipment lists, descriptions, parts lists, etc. to instruct operating and maintenance personnel unfamiliar with such equipment.

B. All operations and maintenance data documents shall be provided in both hardcopy, bounded in separate three ring binders, indexed, tabbed with sectional dividers, and no larger than 8 ½-inch x 11-inch and bookmarked electronic media - Adobe® Acrobat® portable document format. Two sets of hardcopies and two sets of electronic media (3.0 USB flash drive) shall be provided.

C. All operations and maintenance drawings shall be provided in both hardcopy, bounded, indexed, and no larger than 11-inch x 17-inch and bookmarked electronic media - Autodesk® AutoCAD® file format AND Adobe® Acrobat® portable document format. Two sets of hardcopies and two sets of electronic media (3.0 USB flash drive) shall be provided.

D. Manuals shall include the following as a minimum:

1. A comprehensive index;
2. A complete “as-built” set of approved shop drawings;
3. A complete list of the equipment supplied, including Manufacturer, model and serial numbers, ranges and pertinent data;
4. A table listing of the “as left” settings for all electric/electronic components (timing relays, alarm & trip settings);
5. System schematic drawings “as-built”, illustrating all components, piping and electric connections of the system supplied under this Section.
6. Detailed service, maintenance and operation instructions for each item supplied
7. Special maintenance requirements particular to this system shall be clearly defined, along with special calibration and test procedures;
8. The operating instructions shall also incorporate a functional description of the entire system, with references to the systems schematic drawings and instructions;
9. Complete parts list with Manufacturer stock numbers, including spare parts;

1.15 COMPONENT INTERCONNECTIONS

A. Component equipment furnished under this Specification will not be furnished as integrated systems. Contractor shall field install and wire completely all components.

B. Contractor shall analyze all systems components and their shop drawings, identify all terminals and prepare drawings and wiring tables necessary for component interconnection. Contractor shall provide crimp on wire numbers on both ends of all control wiring installed between all panels furnished under this contract. These numbers shall directly relate to the interconnect wiring drawing furnished by the Contractor and be reflected in the record drawings submitted.

1.16 SHOP DRAWINGS

A. Submit shop drawings in accordance with Specification Section 01420.

B. As specified under other sections, shop drawings shall be submitted for approval of all materials, equipment, apparatus, and other items as required by the Engineer.

C. The submittal shall be for the entire Specification Section. If any portion of the section is missing or incomplete, the submittal shall be rejected and resubmitted.

D. All submittal documents shall be provided in both hardcopy, bounded in separate three-ring binders, indexed, tabbed with sectional dividers, and no larger than 8 ½-inch x 11-inch and bookmarked electronic media - Adobe® Acrobat® portable document format. Two sets of hardcopies and two sets of electronic media shall be provided.

E. All drawings shall be provided in both hardcopy, bounded, indexed, and no larger than 11-inch x 17-inch and bookmarked electronic media - Autodesk® AutoCAD® file format AND Adobe® Acrobat® portable document format. Two sets of hardcopies and two sets of electronic media shall be provided.

F. Prior to submittal by the Contractor, all shop drawings shall be checked for accuracy and contract requirements. Shop drawings shall bear the date checked and shall be accompanied by a statement that the shop drawings have been examined for conformity to Specifications and Drawings. This statement shall also list all discrepancies with the Specifications and Drawings. Shop drawings not so checked and noted shall be returned.

G. A copy of each specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with any request for information (RFI) clarifications and/or applicable responses, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check-marks (√) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined shall signify compliance on the part of the Contractor with the

specifications. The submittal shall be accompanied by a detailed, written justification for each deviation.

H. Shop drawings shall be submitted for the following equipment:
   1. Conduit;
   2. Wire and Cables;
   3. Circuit Breakers
   4. (LS) EYSR Fittings;
   5. Tagging Conventions of cables and wires;
   6. Conduit drawings, building and site layouts;

I. The Manufacturer name and product designation and catalog data sheet shall be submitted for the following material:
   1. Conduit;
   2. Receptacles;
   3. Boxes and fittings;
   4. Wiring Devices;
   5. Lamps;

J. The Engineer's check shall be only for conformance with the design concept of the project and compliance with the Specifications and Contract Drawings. The responsibility of, or the necessity of, furnishing materials and workmanship required by the Specifications and Contract Drawings which may not be indicated on the shop drawings is included under the work of this Section.

K. The responsibility for all dimensions to be confirmed and correlated at the job site and for coordination of this work with the work of all other trades is also included under the work of this Section.

L. No material shall be ordered, or shop work started until the Engineer's approval of shop drawings has been given.

1.17 MATERIALS

A. The materials used in all systems shall be new, unused and as hereinafter specified. All materials where not specified shall be of the very best of their respective kinds. Samples of materials or Manufacturer's specifications shall be submitted for approval as required by the Engineer.

B. Materials and equipment used shall be Underwriters Laboratories (UL) Listed.

C. Electrical equipment shall at all times during construction be adequately protected against mechanical injury or damage by water. Electrical equipment shall not be stored out-of-doors. Electrical equipment shall be stored in dry permanent shelters. If any apparatus has been damaged, such damage shall be repaired by the Contractor at his own cost and expense. If any apparatus has been subject to possible injury by water, it shall be thoroughly dried out and put through such special tests as directed by the Engineer, at the expense of the Contractor, or shall be replaced by the Contractor at his own expense.

1.18 DEMOLITION

A. Remove all electrical work associated with equipment scheduled for demolition except those portions indicated to remain or be reused. Remove

all unused exposed conduit and wiring back to point of concealment. Remove unused wiring in concealed conduits back to source (or nearest point of usage). Electrical work to be removed corresponds to the associated mechanical equipment to be removed.

B. Where electrical systems pass through the demolition areas to serve other portions of the premises, they shall remain or shall be suitably relocated, and the system restored to normal operation. Coordinate outages in systems with the City. Where duration of proposed outage cannot be allowed by the City, provide temporary connections as required to maintain service.

C. All removals and relocations of existing installations cannot be completely detailed on the Drawings. Contractor is responsible for determining the exact requirements for the project based upon site investigation.

D. Continuous service is required on all circuits and outlets affected by these changes, except where the City will permit outage for a specific time. Obtain City's written consent before removing any circuit from continuous service.

E. Where required disconnect and/or remove any part of an existing circuit, reconnect that circuit to reestablish service in the remaining portion.

F. Remove exposed conduits, wire ways, outlet boxes, pull boxes and hangers made obsolete by the alternations, unless specifically designated to remain. Exposed conduits shall be removed back to point of concealment, where they shall be cut and threaded for a cap. A threaded cap shall then be installed. Conduits may be removed back to first coupling if within 3-inches of point of concealment. Cut back in traffic areas to the floor level and patch.

1.19 DISPOSITION OF REMOVED MATERIALS AND EQUIPMENT

A. In general, it is intended that all materials and equipment indicated to be removed and disposed of by the Contractor shall, upon removal, become the Contractor's property and shall be disposed of off the site by the Contractor at their expense, unless otherwise directed by the City.

B. Reuse of wire will not be permitted. An exception is the reuse or relocation when wire is part of an existing lighting branch circuit and reuse or relocation is specifically designated and can be accomplished without removing and re-pulling the wire.

C. All electrical equipment to be salvaged shall be removed and moved by the Contractor to a location on the site for storage as directed by the City.

1.20 COORDINATION, SHORT CIRCUIT AND ARC FLASH HAZARD STUDY

A. See Section 16015 - Electrical Systems Analysis for specifics.

1.21 CONDUIT DRAWINGS

A. The Contractor shall submit complete conduit and equipment layout drawings. These ¼-inch = 12-inch scaled layout(s) of the new and existing electrical equipment in the electrical room or major electrical equipment in a mechanical room showing physical sizes of all equipment and their spatial relationships. Nonelectrical equipment shall be approved before finalizing the electrical layout. The drawing shall include the following:

1. Conduit layouts shown on floor plans drawn at not less than ¼-inch = 12-inch scale. The layouts shall include locations of electrical equipment, transformers, panelboards, control panels and equipment, motors, switches, large junction or pull boxes, instruments, and any other electrical devices connected to concealed or buried conduits;
2. Plans shall be drawn on high quality reproducible, size 36-inch x 24-inch, and shall be presented in a neat, professional manner utilizing AutoCAD format. Contractor to submit both hard copies and an electronic copy for approval;
3. Concrete floors and/or walls containing concealed conduits shall not be poured until conduit layouts are approved;

B. In addition to the manufacturer's equipment shop drawings, the Contractor shall submit for the approval, electrical working drawings for the overall site work containing the following:
1. Concealed and buried conduit layouts shown on plans drawn at not less than 1-inch = 30-foot-0-inch scale. The layouts shall include locations of cabling, transformers, manholes, conduit sleeves and any other electrical devices required;
2. Plans shall be drawn on high quality reproducible, size 36-inch x 24-inch, and shall be presented in a neat, professional manner utilizing AutoCAD format. Contractor to submit both hard copies and an electronic copy (AutoCAD format) for approval;
3. Ductbanks shall not be poured until conduit layouts are approved;

C. Existing AutoCAD drawing files are available from the Engineer.

1.22 WARRANTY

A. Provide a warranty for all the electrical equipment in accordance with the requirements of the other Division 16 Sections, but in no case less than one (1) year from the date of Substantial Completion.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

End of Section

Section 16015

ELECTRICAL SYSTEMS ANALYSIS

PART 1 - GENERAL

1.1 SCOPE

A. The requirements of this specification shall apply to the new electrical distribution system for the City. The end result shall be a fully protected and properly coordinated system with proper arc flash safety labels and personal protective equipment recommendations.

B. The Contractor shall furnish a Short-Circuit Study and a Protective Device Coordination Study as described herein. The Protective Device Coordination Study shall begin with the utility company's feeder protective device and include all of the electrical protective devices down to, and including, the main breaker and feeder circuits in each panelboard. The study shall also include transformers, variable frequency drives, reduced-voltage starters, emergency and/or standby generators, distribution switchgear and protective devices.

C. The Contractor shall furnish an Arc Flash Hazard Analysis Study per NFPA 70E® - Electrical Safety in the Workplace, reference Article 130.3 and Annex D.

1.2 REFERENCES

A. All characteristics, definitions, and terminology, except as specifically covered in this specification, shall be in accordance with the latest revision of the following standards:

1. American National Standards Institute (ANSI) C37.010 – Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis (includes supplements ANSI/IEEE C37.010b and C37.010d);
2. ANSI C37.5 – Methods for Determining the RMS Value of a Sinusoidal Current Wave and Normal-Frequency Recovery Voltage and for Simplified Calculation of Fault Currents;
3. ANSI C37.10 - IEEE Guide for Diagnostics and Failure Investigation of Power Circuit Breakers;
4. ANSI C37.13 – Low Voltage AC Power Circuit Breakers Used in Enclosures;
5. ANSI C37.41 – Standard Design Tests for High Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches and Accessories;
6. ANSI C57.12.00 - IEEE General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers;
7. Institute of Electrical and Electronics Engineers (IEEE) 141 – Recommended Practice for Electric Power Distribution and Coordination of Industrial and Commercial Power Systems;

8. IEEE 241 – Recommended Practice for Electric Power Systems in Commercial Buildings;
9. IEEE 242 - Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems;
10. IEEE 399 - Recommended Practice for Industrial and Commercial Power System Analysis;
11. IEEE 1015 – Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems;
12. IEEE 1584 - Guide for Performing Arc Flash Hazard Calculations;
13. National Fire Protection Association® (NFPA) 70 – National Electric Code® (NEC®);
14. NEC® Article 409 – Industrial Control Panels;
15. NFPA® 70E® - Electrical Safety in the Workplace;
16. Occupational Safety & Health Administration (OSHA) 29-CFR, Part 1910, sub part S;
17. UL 508A - Industrial Control Panels;

1.3 SUBMITTALS

A. Submit shop drawings in accordance with the General Conditions and Section 01420.
   1. The results of the Short-Circuit Study; Protective Device Coordination Study and Arc Flash Analysis shall be summarized in a preliminary and final summary report.
   2. All submittal documents shall be provided in both hardcopy, bounded in separate three-ring binders, indexed, tabbed with sectional dividers, and no larger than 8 ½-inch x 11-inch (11-inch x 17-inch drawings and tables are permitted) and bookmarked electronic media - Adobe® Acrobat® portable document format. Two sets of hardcopies and two sets of electronic media shall be provided.
   3. All drawings shall be provided in both hardcopy, bounded, indexed, and no larger than 11-inch x 17-inch and bookmarked electronic media - Autodesk® AutoCAD® file format AND Adobe® Acrobat® portable document format shall be provided. Two sets of hardcopies and two sets of electronic media shall be provided.
   4. All Power Systems Design & Analysis “source” files in electronic format shall be provided to the City.
   5. The preliminary Short-Circuit Study and Protective Device Coordination Study shall be submitted within 30-days of Notice to Proceed and shall form the basis for approval of all other electrical equipment in the power distribution system.
   6. The Contractor is expected to review the results of the preliminary Short-Circuit Study and Protective Device Coordination Study against all other applicable shop drawings, including industrial control panels, prior to shop drawing submittal to coordinate appropriate fault duty ratings of all electrical equipment.

7. The final Short Circuit Study and Protective Device Coordination Study shall incorporate all comments from the shop drawing submittals and include the Arc Flash Analysis.
8. The Contractor shall ensure proper, permanent adhesive non-fading and complete Arc Flash warning labels are applied to all appropriate electrical equipment installed under this contract when the final studies have been approved.

1.4 STUDY SCHEDULE

A. The preliminary (initial), complete Short Circuit Study and Protective Device Coordination Study must be submitted and reviewed before Engineer will approve Shop Drawings for switchgear, unit sub stations, breakers, MCCs, switchboards, VFDs, manufactured industrial control panels and circuit breaker panelboard equipment. Failure to do so will delay the approval of major equipment submittals.
B. The Short Circuit Study, the Protective Device Coordination Study and the Arc Flash Analysis shall be updated prior to Project Substantial Completion. The final studies shall utilize characteristics of as-installed equipment actual wire run lengths and materials.

PART 2 - PRODUCTS

2.1 GENERAL

A. Contractor shall furnish all field data (feeder cable sizes, approximate feeder length motor data, generator data, existing relay settings, etc.) as required for the power system studies. The Engineer performing the Short Circuit Study, the Protective Device Coordination Study and the Arc Flash Analysis shall furnish the Contractor with a listing of required data immediately after Contract Award. The Contractor shall expedite collection of the data to eliminate unnecessary delays and assure completion of the studies as required for final approval of the distribution equipment shop drawings and/or prior to the release of the equipment for manufacturing.
B. Source combination may include present and future utility supplies, motors, and generators.
C. Load data utilized may include existing and proposed loads obtained from the Contract Documents provided by City or Contractor.
D. Equipment and component titles used in the studies shall be identical to the equipment and component titles shown on the Drawings.
E. Perform studies using digital computer with a software package such as SKM SYSTEMS ANALYSIS, INC. (SKM) Power*Tools for Windows®.
F. Perform complete fault calculations for all busses on utility and generator power sources. Perform load flow and voltage drop studies for major feeders and loads with long feeder runs. Analysis shall include expected fault currents at industrial control panels manufactured in accordance with UL 508A and NEC® Article 409.
G. Fault source combinations shall include large motors, large transformers, utility and generator.

H. Utilize proposed and existing load data for the study obtained from Contract Documents and field survey. Coordinate with local power utility for available fault currents from utility services.
I. Existing Equipment:
J. Provide a comprehensive document containing the Short Circuit Study, the Protective Device Coordination Study and the Arc Flash Analysis. As a minimum the report structure shall contain:
   1. Executive Summary;
   2. Methodology;
   3. One Line Diagram(s);
   4. Short Circuit Analysis;
   5. Short Circuit Analysis Results/Conclusions/Recommendations;
   6. Protective Device Coordination Analysis;
   7. Recommended protective devices settings;
   8. Arc Flash Analysis;
   9. Arc Flash PPE recommendations;
K. Acceptable Electrical Systems Analysis Software Manufacturers
   SKM SYSTEMS ANALYSIS INC.www.skm.com
   1. Power*Tools for Windows®
   2. (Use latest version of PTW available at time of Contract Award)
   3. Power Systems Design & Analysis Suite of Modules;
   4. SKM DAPPER® Short Circuit Study;
   5. SKM CAPTOR Protective Device Coordination Study;
   6. SKM ARC FLASH Analysis;
   7. NO EQUAL

2.2 SHORT CIRCUIT STUDY

A. General:
   1. Use cable impedances based on copper conductors. Use actual conductor impedances, if known. If unknown, use typical conductor impedances based on IEEE Standards 141, latest edition.
   2. Use bus impedances based on copper bus bars.
   3. Use cable and bus resistances calculated at 77 °F (25 °C).
   4. Use 600-volt cable reactance's based on use of typical data of conductors to be used on this project.
   5. Use transformer impedances 92.5% of "nominal" impedance based on tolerances specified in ANSI C57.12.00.
B. Provide:
   1. Calculation methods and assumptions.
   2. Selected base per unit quantities.
   3. One-line diagrams annotated with results of short circuit analysis including:
      a. Three phase, line-to-line and single line to ground faults.
      b. Equipment Short Circuit Rating.
   4. Source impedance data, including electric utility system and motor fault contribution characteristics.

5. DAPPER® Short circuit report, demand load report, load flow report and input data reports.
6. Results, conclusions and recommendations.

C. Calculate short circuit interrupting and momentary (when applicable) duties for an assumed symmetrical three-phase bolted fault, bolted line-to-ground fault, and bolted line-to-line fault at each:
1. Electric utility's supply termination point.
2. Main breakers, generator breakers and feeder breakers.
3. Low voltage switchgear, switchboard and/or distribution panelboard.
4. Unit substations.
5. Motor control centers.
6. Standby generator.
7. Automatic Transfer Switch (if applicable).
8. All branch circuit panelboards.
9. Variable Frequency Drives.
10. Industrial control panels manufactured in accordance with UL 508A and NEC® Article 409.
11. Other significant locations throughout the system.
12. Future load contributions as shown on one-line diagram.

D. Protective Device Evaluation:
1. Evaluate equipment and protective devices and compare to short circuit ratings Verify all equipment, main breakers, ATS, and protective devices are applied within their ratings.
2. Adequacy of switchgear, switchboards, motor control centers, unit substations and panelboard bus bar bracing to withstand short-circuit stresses
3. Adequacy of transformer windings to withstand short-circuit stresses
4. Cable and busway sizes for ability to withstand short-circuit heating besides normal load currents.
5. Notify City in writing, of existing, circuit protective devices improperly rated for the calculated available fault current

E. Through the Contractor, furnish expected fault currents for industrial control panels, constructed and installed under other divisions and specifications of this contract, to the panel builder for their coordination with meeting the requirements of UL 508A and NEC® Article 409.

2.3 PROTECTIVE DEVICE COORDINATION STUDY

A. Proposed protective device coordination time-current curves for distribution system, graphically displayed on log-log scale paper. Time-Current Curve plots from SKM CAPTOR program are acceptable.

B. Each curve sheet to have title and one-line diagram with legend identifying the specific portion of system associated with time-current curves on that sheet.

C. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which device is exposed.

D. Identify device associated with each curve by Manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
E. Perform device coordination on time-current curves for low voltage distribution system(s).
F. Provide Individual protective device time-current characteristics on log-log paper or software generated graphs.
G. Plot Characteristics on Curve Sheets:
    1. Electric utility's relays or protective device (if applicable).
    2. Electric utility's fuses including Manufacturer's minimum melt, total clearing, tolerance, and damage bands (if applicable).
    3. Low voltage fuses including Manufacturer's minimum melt, total clearing, tolerance, and damage bands.
    4. Low voltage equipment circuit breaker trip devices, including Manufacturer’s tolerance bands.
    5. Transformer full-load current, magnetizing inrush current, and ANSI transformer withstand parameters.
    6. Transformer damage curves.
    7. Conductor damage curves.
    8. ANSI transformer with stand parameters.
    9. Significant symmetrical and asymmetrical fault currents.
    10. Ground fault protective devices and settings (if applicable).
    11. Pertinent motor starting characteristics and motor damage points.
    12. Pertinent generator short circuit decrement curve and generator damage point.
    13. Circuit breaker panelboard main breakers, where appropriate.
    14. Motor circuit protectors for major motors
H. Provide adequate time margins between device characteristics such that selective operation is provided, while providing proper protection.
I. Primary Protective Device Settings for Delta-Wye Connected Transformer:
    1. Secondary Line-to-Ground Fault Protection: Primary protective device operating band within the transformer's characteristics curve, including a point equal to 58 percent of ANSI C57.12.00 withstand point.
    2. Secondary Line-To-Line Faults: 16 percent current margin between primary protective device and associated secondary device characteristic curves.

2.4 ARC FLASH ANALYSIS

A. Perform incident energy calculations in accordance with IEEE 1584-2002 – Guide for Performing Arc Flash Hazard Calculations for all equipment analyzed in the Short Circuit Study. Tabular results and recommended labels from SKM ARC FLASH are acceptable.
B. Where appropriate, the short circuit calculations and the clearing times of the phase overcurrent devices will be retrieved from the Short Circuit and the Protective Device Coordination Studies;
C. The flash protection boundary and the incident energy shall be calculated at all significant locations in the electrical distribution system (switchboards,

switchgear, motor-control centers, panelboards, busway and unit substations, variable frequency drives, and industrial control panels) where work could be performed on energized parts.

D. The Arc Flash Hazard Analysis shall include all low voltage (600V and below) and significant locations in 240 volts and 208VAC systems fed from transformers equal to or greater than 125 kVA. Arc Flash Hazard Analysis on low voltage systems 120VAC and below is not required.

E. Safe working distances shall be specified for calculated fault locations based upon the calculated arc flash boundary considering incident energy of 1.2 cal/cm2;

F. The Arc Flash Analysis shall include calculations for maximum and minimum contributions of fault current magnitude. The minimum calculation shall assume that the utility contribution is at a minimum and shall assume a minimum motor load. Conversely, the maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.

G. Arc flash computation shall include both line and load side of main breaker calculations, where necessary.

H. Arc Flash calculations shall be based on actual overcurrent protective device clearing time. Maximum clearing time will be capped at 2 seconds based on IEEE 1584-2002 section B.1.2.

I. Furnish recommendations for Personal Protective Equipment (PPE), in accordance with OSHA standards, and proper complete labels to be located on the electrical equipment in accordance with NEC® Article 110.16.

J. Use Manufacturer data for: enclosure type; gap between exposed conductors or busway; grounding type; number of phases and connection; and working distance.

2.5 TABULATIONS

A. Input Data:
   1. Utility three-phase and line-to-ground available contribution with associated X/R ratios;
   2. Short circuit reactance’s of rotating machines and associated X/R ratios;
   3. Cable type, construction, size, quantity per phase, length, impedance and conduit type;
   4. Bus data, including impedance;
   5. Transformer primary & secondary voltages, winding configurations, kVA rating, impedance, and X/R ratio;

B. Short Circuit Data:
   1. Source fault impedance and generator contributions;
   2. X to R ratios;
   3. Asymmetry factors;
   4. Motor contributions;
   5. Short circuit kVA;
   6. Symmetrical and asymmetrical fault currents;

C. Recommended Protective Device Settings:
   1. Phase and ground relays:
      a. Relay name;
      b. Device number;
      c. Description;
      d. TCC catalog number;
      e. Short circuit ratings;
      f. Current transformer ratio;
      g. Current tap;
      h. Time dial setting (as applicable);
      i. Instantaneous pickup setting (as applicable);
      j. Ground fault setting (as applicable);
      k. Specialty, non-overcurrent device settings;
      l. Recommendations on improved relaying systems, if applicable;
   2. Circuit Breakers:
      a. Breaker name;
      b. Breaker Description;
      c. Model number;
      d. TCC catalog number;
      e. Short circuit rating;
      f. Frame/Sensor rating;
      g. Adjustable pickups and time delays (long time, short time, ground);
      h. Adjustable time-current characteristic;
      i. Adjustable instantaneous pickup;
      j. Recommendations on improved trip systems, if applicable;
   3. Motor Circuit Protectors (MCP):
      a. MCP name;
      b. MCP Description;
      c. Model number;
      d. TCC catalog number;
      e. Short circuit rating;
      f. Frame/Sensor rating;
      g. Instantaneous settings;
   4. Fuses:
      a. Fuse name;
      b. Fuse Description;
      c. Model number;
      d. TCC catalog number;
      e. Short circuit rating;
      f. Fuse rating;
D. Incident energy and flash protection boundary calculations.
   1. Arcing fault magnitude;
   2. Device clearing time;
   3. Duration of arc;
   4. Arc flash boundary;
   5. Working distance;

6. Incident energy;
7. Hazard Risk Category;
8. Recommendations for arc flash energy reduction;

2.6 STUDY ANALYSES

A. Written Summary:
   1. Scope of studies performed;
   2. Explanation of bus and branch numbering system;
   3. Prevailing conditions;
   4. Selected equipment deficiencies;
   5. Results of short circuit and coordination studies;
   6. Comments or suggestions;
B. Suggest changes and additions to equipment rating and/or characteristics.
C. Notify Engineer in writing of existing circuit protective devices improperly rated for new fault conditions.

PART 3 - EXECUTION

3.1 GENERAL

A. Adjust relay and protective device settings according to values established by coordination study.
B. Make minor modifications to equipment as required accomplishing conformance with the Short Circuit Study and the Protective Device Coordination Study.
C. Notify Engineer in writing of any required major equipment modifications.

End of Section

Section 16040

ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.1 SCOPE

A. Extent of electrical identification work is indicated by drawings and schedules, or items listed in this specification.

B. Related Work Specified Elsewhere (if included):
   1. Division 1 – General Requirements;
   2. Division 2 – Site Work;
   3. Division 3 – Concrete;
   4. Division 11 – Equipment;
   5. Division 13 – Special Construction;
   6. Division 15 – Mechanical;
   7. Division 16 – Electrical;

C. Types of electrical identification work specified in this section include the following:
   1. Electrical power, control and communication conductors;
   2. Operational instructions and warnings;
   3. Danger signs;
   4. Equipment/System Identification signs or tags;

1.2 REFERENCES

A. All characteristics, definitions, and terminology, except as specifically covered in this specification, shall be in accordance with the latest revision of the following standards:
   1. American National Standards Institute (ANSI) A13.1 - Scheme for the Identification of Piping Systems;
   2. ANSI Z53.1 - Color Designation;
   3. National Fire Protection Association® (NFPA®) 70 – National Electrical Code® (NEC®);
   4. NEC® Article 110 – Requirements for Electrical Installations;
   5. NEC® Article 200 – Use and Identification of Grounded Conductors;
   6. NEC® Article 210 – Branch Circuits;
   7. NEC® Article 215 – Feeders;
   8. NEC® Article 230 – Services;
   9. NEC® Article 250 – Grounding and Bonding;
   10. NEC® Article 310 – Conductors for General Wiring;
   11. NEC® Article 400 – Flexible Cords and Cables;
   12. NEC® Article 408 – Switchboards and Panelboards;
   13. NEC® Article 504 – Intrinsically Safe Systems;
   14. NEC® Article 647 – Sensitive Electronic Equipment;
   15. NEC® Article 708 – Critical Operations Power Systems;
   16. National Electrical Contractors Association (NECA) National Electrical Installation Standards (NEIS);

17. NFPA® 70E® - Electrical Safety in the Workplace;
18. Underwriters Laboratories (UL) 969 - Marking and Labeling Systems;

1.3 SUBMITTALS

A. Submit shop drawings in accordance with the General Conditions and Section 01420.
B. All submittal documents shall be provided in both hardcopy, bounded in separate three-ring binders, indexed, tabbed with sectional dividers, and no larger than 8½-inch x 11-inch and bookmarked electronic media - Adobe® Acrobat® portable document format. Two sets of hardcopies and two sets of electronic media shall be provided.
C. All drawings shall be provided in both hardcopy, bounded, indexed, and no larger than 11-inch x 17-inch and bookmarked electronic media - Autodesk® AutoCAD® file format AND Adobe® Acrobat® portable document format. Two sets of hardcopies and two sets of electronic media shall be provided.
D. The following information, at a minimum, shall be submitted to the City:
    1. Descriptive bulletins;
    2. Product data sheets;
    3. Master drawing index;
    4. Dimensioned front & plan view of the assembly;
    5. Installation information;

1.4 QUALITY ASSURANCE

A. Manufacturers: Firms regularly engaged in manufacturing of electrical identification products of types required, whose products have been satisfactory use in similar service for not less than 3 years.
B. Installer's Qualifications: Firm with at least 3 years of successful installation experience with projects utilizing electrical identification work similar to that required for this project.
C. NEC® Compliance: Comply with NEC® as applicable to installation of identifying labels and markers for wiring and equipment.
D. UL Compliance: Comply with applicable requirements of UL 969 - Marking and Labeling Systems, pertaining to electrical identification systems.
E. ANSI Compliance: Comply with applicable requirements of ANSI Standard A13.1 - Scheme for the Identification of Piping Systems, and ANSI Standard Z53.1 - Color Designation.

PART 2 - PRODUCTS

2.1 ELECTRICAL IDENTIFICATION MATERIALS

A. Except as otherwise indicated, Contractor shall provide Manufacturer's standard products of categories and types required for each application. Where more than a single type is specified for an application, the selection Contractor’s option, but provide single selection for each application.
B. Conduit System Markers:
    1. Plastic Markers: Provide Manufacturer's standard pre-printed, flexible or semi rigid, permanent, conduit markers, extending 360° around

conduits; designed for attachment to conduit by adhesive, adhesive lap joint of marker, matching adhesive plastic tape at each end of marker, or pretension snap-on.

2. Voltage Marking: Except as otherwise indicated, provide lettering that indicates voltage of the conductor(s) in conduit.
   a. Provide 4-inch minimum length with 7/8-inch minimum lettering for 2-inch and smaller conduit.

   b. Provide 8-inch minimum length with 1-7/8-inch minimum lettering for larger than 2-inch conduit.

3. Painted Band: Provide painted band in color to match plastic markers or tape.

C. Cable/Conductor Identification Bands:
   1. Provide Manufacturer's standard aluminum wrap-around cable/conductor markers, of size required for proper application, and numbered to show circuit identification.
   2. Provide Manufacturer's standard vinyl cloth self-adhesive cable/conductor markers of the wrap-around type; either pre-numbered plastic-coated type or write-on type with clear plastic self-adhesive cover flap; numbered to show circuit identification.

D. Plasticized Tags:
   1. Provide Manufacturer's standard preprinted or partially preprinted accident prevention and operation tags, of plasticized card stock with matt finish suitable for writing, approximately 3¼-inch x 5-5/8-inch, with brass grommets and wire fasteners, and with appropriate pre-printed wording including large size primary wording, e.g., DANGER, CAUTION, DO NOT OPERATE.

E. Baked Enamel Danger Signs:
   1. Provide Manufacturer's standard "DANGER" signs of baked enamel finish on 20 gauge steel; of standard red, black and white graphics; 14-inch x 10-inch size except where 10-inch x 7-inch is the largest size which can be applied where needed, and except where larger size is needed for adequate vision; with recognized standard explanation

wording, e.g. HIGH VOLTAGE, KEEP AWAY, BURIED CABLE, DO NOT TOUCH SWITCH.

F. Engraved Plastic Laminate Nameplates:
1. Provide engraving stock melamine or phenolic plastic laminate, in sizes and thickness indicated, engraved with engraver's standard letter style of the sizes and working indicated, black face and white core plies (letter color) except as otherwise indicated on drawings, or where noted in the specification. Punch for mechanical fastening.
   a. Thickness: 1/8-inch, except as otherwise noted.
   b. Fasteners: Self-tapping stainless-steel screws or brass bolts.

G. Underground Type Plastic Line Marker:
1. Manufacturer's standard permanent, magnetic bright colored, continuous printed, metal backed plastic tape, intended for direct burial service; not less than 6-inches wide x 4 mils thick. Provide tape with printing which most accurately indicates the type of service or buried cable.

2.2 LETTERING AND GRAPHICS

A. General Installation Requirements:
1. Installation: Install electrical identification products as indicated, in accordance with Manufacturer's written instructions, and requirements of NEC®.
2. Coordination: Where identification is to be applied to surfaces which require a field finish application, install identification after completion of such application.
3. Regulations: Comply with governing regulations and requests of governing authorities for the identification of electrical work.

2.3 ACCEPTABLE ELECTRICAL IDENTIFICATION MANUFACTURERS

A. The listing of specific Manufacturers does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed are not relieved from meeting these specifications in

their entirety. Products in compliance with the specification and manufactured by others not named will be considered only if pre-approved by the City ten (10) days prior to bid date.

1. CARLTON INDUSTRIES, LP
   www.carltonusa.com
   (800) 231-5988
2. IDEAL® INDUSTRIES, INC.
   www.idealindustries.com
   (800) 435-0705
3. NATIONAL BAND AND TAG
   www.nationalband.com
   (859) 581-8247
4. PANDUIT® CORP.
   www.panduit.com
   (800) 777-3300
   (708) 532-1800
5. SETON IDENTIFICATION PRODUCTS
   www.seton.com
   (800) 571-2596
6. THOMAS AND BETTS CO.
   www.tnb.com
   (888) 862-3289
7. City Preapproved Equal

2.4 LOCAL IDENTIFICATION MANUFACTURERS

A. These firms have been used in the past and provided products acceptable to the City

1. FLORIDA MARKING PRODUCTS INC.
   www.floridamarking.com
   (407) 834-3000
2. THE CUTTING EDGE
   www.cuttingedgeinc.com
   (800) 962-2376
   (440) 259-2581
3. City Preapproved Equal

PART 3 - EXECUTION

3.1 RACEWAY SYSTEM IDENTIFICATION

A. Where electrical conduit is exposed in spaces with exposed mechanical piping, and the mechanical piping is identified by color-coding method, apply color-coded identification on electrical conduit in manner similar to piping identification. Orientation of all labels shall be of the same orientation.

1. Except as otherwise indicated, use white as the coded color for conduit.
2. Identify the following services:

Service	Label
Low Voltage	208/120V
High Voltage	480/277V

3.2 CABLE/CONDUCTOR IDENTIFICATION

A. Apply cable/conductor identification, including voltage, phase and feeder number, on each cable/conductor in each box/enclosure/cabinet where wires of more than one circuit or communication (such as color coded conductors) is provided. Match identification with marking system used in panel board, shop drawings, contract documents, and similar previously established identification for project's electrical work.

B. Color code all power and lighting cable. Use wire colored by integral pigmentation, making the wire 100% colored. Where not practicable or available (in larger conductor sizes), color code the wire by using colored plastic tape, painting the ends accessible at junction or pull boxes, or other method acceptable to the Engineer. Use the following chart as applicable:

Conductor	208/120V	480/277V
Phase A	Black	Brown
Phase B	Red	Orange
Phase C	Blue	Yellow
Neutral	White	Gray
Ground	Green	Green with Yellow Tracer

3.3 OPERATIONAL IDENTIFICATION AND WARNINGS

A. Wherever warning of electrically connected equipment exists, and signage would prevent misuse of electrical facilities by unauthorized personnel.
   1. Install self-adhesive plastic signs or similar equivalent identification, instruction or warnings on switches, outlets and other controls, devices and covers of electrical enclosures. Where detailed instructions or explanations are needed, provide plasticized tags with clearly written messages adequate for the intended purposes.

B. Danger Signs:
   1. Locations: In addition to installation of danger signs required by governing regulations and authorities, install appropriate danger signs at locations indicated and at location subsequently identified as constituting dangers for person in or about project.
   2. High Voltage: Install danger signs wherever it is possible, under any circumstances, for persons to come into contact with electrical power of voltages higher than 120-Volts.
   3. Critical Switches/Controls: Install danger signs on switches and similar controls, regardless of whether concealed or locked up, where untimely or inadvertent operation (by anyone) could result in significant danger to persons, or damage to or loss or property.
   4. Electrical Equipment Rooms: Provide warning signage at the entrance to each such room.

C. Equipment Identification:

1. Nameplates: Install an engraved plastic laminate nameplate on each unit of electrical equipment in the building: including central or master unit of each electrical system including communication and/or control systems, unless unit is specified with its own self-explanatory identification or signal system. Except as otherwise indicated, provide single line of text, 1-inch high while lettering in back field. Provide text matching terminology and numbering of the contract documents and shop drawings.
2. Provide nameplates for each unit of the following categories of electrical work:
    a. Panelboard, electrical cabinets and enclosures - Provide a nameplate inside, outside and above the door (if equipped with one) of each listing its designation, voltage and feeder and circuit number. Nameplate shall designate source and circuit number of feeder. (Label existing equipment located in same space or room as new equipment being installed.)
    b. Access panel/doors to electrical facilities.
    c. Major electrical switchgear, switchboards and motor control centers.
    d. Disconnect switches.
3. Install nameplates at locations indicated or, where not otherwise indicated, at location for best convenience of viewing without interference with operation and maintenance of equipment.
    a. Secure to substrate with fasteners, except use adhesive where fasteners should not or cannot penetrate substrate.
    b. Designate branch of essential power system (i.e. Life Safety, Critical, or Equipment branch) on nameplate after the word emergency, and board designation.
    c. Color code nameplates as follows:
        1) General Information shall be Black;
        2) Circuit Information 120/208VAC shall be Gray;
        3) Circuit Information 277/480VAC shall be Orange

End of Section

Section 16050

BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 SCOPE

A. This Section describes the Basic Electrical Materials and Methods that shall be used throughout this project.

B. Related Work Specified Elsewhere (if included):

1. Division 1 – General Requirements;
2. Division 2 – Site Work;
3. Division 3 – Concrete;
4. Division 11 – Equipment;
5. Division 13 – Special Construction;
   a. Section 13310 - Programmable Logic Controller (PLC) and Digital Equipment;
   b. Section 13315 – Field Instrumentation;
6. Division 15 – Mechanical;
7. Division 16 – Electrical;

1.2 REFERENCES

A. All characteristics, definitions, and terminology, except as specifically covered in this specification, shall be in accordance with the latest revision of the following standards:

1. American National Standards Institute (ANSI) C55.1 - Shunt Power Capacitors;
2. ANSI C62.11 - Metal-Oxide Surge Arrestors for AC Circuits;
3. ANSI Z55.1 - Gray Finishes for Industrial Apparatus and Equipment;
4. ANSI/ Society of Cable Telecommunications Engineers (SCTE) 77 - Specification for Underground Enclosure Integrity, Tier 8 (12,000# Test Load); Tier 15 (22,500# Test Load) and Tier 22 (33,750# Test Load);
5. American Society for Testing and Materials (ASTM) A167 - Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip;
6. ASTM A240 - Standard Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels;
7. ASTM A570 - Standard Specification for Steel, Sheet, and Strip, Carbon, Hot-Rolled, Structural Quality;
8. Federal Specifications (FS) W-C-596 - Connector, Receptacle, Electrical;
9. FS W-C-596 - Electrical Power Connectors;
10. FS W-S-896E - Switches, Toggle, Flush Mounted;
11. National Electrical Contractors Association (NECA) National Electrical Installation Standards (NEIS);

12. NECA 1 - Standard Practice of Good Workmanship in Electrical Construction;
13. NECA 420 - Standard for Fuse Applications;
14. NECA 409 - Standard for Installing and Maintaining Dry-Type Transformers;
15. National Electrical Manufacturers Association (NEMA) 250 - Enclosures for Electrical Equipment (1000-Volts Maximum);
16. NEC® Chapter 3 – Wiring Methods and Materials;
17. NEC® Article 450 – Transformers and Transformer Vaults (Including Secondary Ties);
18. NEC® Article 500 – Hazardous (Classified) Locations, Classes I, II and III, Division 1 and 2;
19. NEC® Article 501 – Class I Locations;
20. NEC® Article 504 – Intrinsically Safe Systems;
21. NEC® Article 505 – Class I, Zone 0, 1 and 2 Locations;
22. NEMA AB 1 - Molded Case Circuit Breakers and Molded Case Switches;
23. NEMA CP I - Shunt Capacitors;
24. NEMA ICS 2 - Industrial Control Devices, Controllers and Assemblies;
25. NEMA KS 1 - Enclosed Switches;
26. NEMA LA I - Surge Arrestors;
27. NEMA PB 1 - Panelboards;
28. NEMA ST 20 - Dry-Type Transformers for General Applications;
29. NEMA WD I - General Requirements for Wiring Devices;
30. National Fire Protection Association® (NFPA®) 70 – National Electrical Code® (NEC®);
31. NFPA® 70E® - Electrical Safety in the Workplace;
32. NFPA® 72 - National Fire Alarm Code;
33. Underwriters Laboratories (UL) 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations;
34. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations;
35. UL 67 - Panelboards;
36. UL 98 - Enclosed and Dead-Front Switches;
37. UL 198C - Safety High-Interrupting-Capacity Fuses, Current-Limiting Types;
38. UL 198E - Class Q Fuses;
39. UL 248-1 - Low-Voltage Fuses - Part 1: General Requirements;
40. UL 248-2 - Low-Voltage Fuses - Part 2: Class C Fuses;
41. UL 248-3 - Low-Voltage Fuses - Part 2: Class C Fuses;
42. UL 248-4 - Low-Voltage Fuses - Part 4: Class CC Fuses;
43. UL 248-5 - Low-Voltage Fuses - Part 5: Class G Fuses;
44. UL 248-6 - Low-Voltage Fuses - Part 6: Class H Non-Renewable;
45. UL 248-7 - Low-Voltage Fuses - Part 7: Class H Renewable Fuse;
46. UL 248-8 - Low-Voltage Fuses - Part 8: Class J Fuses;
47. UL 248-9 - Low-Voltage Fuses - Part 9: Class K Fuses;
48. UL 248-10 - Low-Voltage Fuses - Part 10: Class L Fuses;

49. UL 248-11 - Low-Voltage Fuses - Part 11: Plug Fuses;
50. UL 248-12 - Low-Voltage Fuses - Part 12: Class R Fuses;
51. UL 248-13 - Low-Voltage Fuses - Part 13: Semiconductor Fuses;
52. UL 248-14 - Low-Voltage Fuses - Part 14: Supplemental Fuses;
53. UL 248-15 - Low-Voltage Fuses - Part 15: Class T Fuses;
54. UL 248-16 - Low-Voltage Fuses - Part 16: Test Limiters;
55. UL 310 - Electrical Quick-Connect Terminals;
56. UL 347 - Alternating Current Contactors and Contactor-Based;
57. UL 486A-486B - Wire Connectors;
58. UL 486C - Splicing Wire Connectors;
59. UL 486D - Sealed Wire Connector Systems;
60. UL 486E - Equipment Wiring Terminals;
61. UL 489 - Molded Case Circuit Breakers and Circuit Breaker Enclosures;
62. UL 498 - Attachment Plugs and Receptacles;
63. UL 508A - Industrial Control Equipment;
64. UL 810 - Capacitors;
65. UL 943 - Ground-Fault Circuit Interrupters;
66. UL 1059 - Terminal Blocks;
67. UL 1561 - Dry-Type General-Purpose and Power Transformers;
68. UL 4248-1 - Fuseholders - Part 1: General Requirements;
69. UL 4248-4 - Fuseholders - Part 4: Class CC;
70. UL 4248-5 - Fuseholders - Part 5: Class G;
71. UL 4248-6 - Fuseholders - Part 6: Class H;
72. UL 4248-8 - Fuseholders - Part 8: Class J;
73. UL 4248-9 - Fuseholders - Part 9: Class K;
74. UL 4248-11 - Fuseholders - Part 11: Type C (Edison Base);
75. UL 4248-12 - Fuseholders - Part 12: Class R;
76. UL 4248-15 - Fuseholders - Part 15: Class T;
77. UL 62275 - Cable management systems - Cable ties for electrical;

1.3 SUBMITTALS

A. Submit shop drawings in accordance with the General Conditions and Section 01420.
B. All submittal documents shall be provided in both hardcopy, bounded in separate three-ring binders, indexed, tabbed with sectional dividers, and no larger than 8½-inch x 11-inch and bookmarked electronic media - Adobe® Acrobat® portable document format. Two sets of hardcopies and two sets of electronic media shall be provided.
C. All drawings shall be provided in both hardcopy, bounded, indexed, and no larger than 11-inch x 17-inch and bookmarked electronic media - Autodesk® AutoCAD® file format AND Adobe® Acrobat® portable document format. Two sets of hardcopies and two sets of electronic media shall be provided.
D. Shop Drawings:
    1. Device boxes for use in hazardous areas.
    2. Junction and pull boxes used at, or below, grade.
    3. Device box relocation.

4. Terminal junction boxes.
5. Circuit breaker data.
6. Fuses.
7. Contactors.
8. Transformers.
9. All other miscellaneous material part of this project.

E. The following information, at a minimum, shall be submitted to the City:
1. Descriptive bulletins;
2. Product data sheets;
3. Cable terminal sizes;
4. Component list;
5. Wiring diagrams;
6. Installation information;

F. Quality Control Submittals:
1. Test Report: Sound test certification for dry type power transformers (0 to 600-volt, primary).

1.4 QUALITY ASSURANCE

A. The Manufacturer shall have a minimum of ten (10) years consecutive experience producing similar electrical equipment.
B. The Manufacturer shall be ISO certified.
C. UL Listing Requirements –
1. “Manufactured in accordance with” is not equivalent to “UL LISTED” and does not meet the intent of this specification;
2. The Electrical materials shall be posted at www.UL.com under the appropriate Category Code. Products without posting at UL.com shall not be approved. To access UL Category Code, click on Certifications of UL’s home page. Type the appropriate code into the Category Code search box and click Search.
D. Hazardous Areas: Materials and devices shall be specifically approved for hazardous areas of the class, division, and group shown and of a construction that will ensure safe performance when properly used and maintained.

1.5 DELIVERY, STORAGE AND HANDLING

A. Deliver products and equipment in factory labeled packages that include recommended storage practices placed on the outside of the shipping container.
B. Handling and shipment of the products and equipment shall be in such a manner to prevent internal component damage, breakage, and denting and scoring of the enclosure finish.
C. Store and handle in strict compliance with Manufacturer’s instructions and recommendations. Protect from potential damage from weather and construction operations. Store so condensation will not form on or in equipment and if necessary, apply temporary heat where required to obtain suitable service conditions.

1.6 SPARE PARTS

A. Furnish, tag and box for shipment and storage the following spare parts:
   1. Fuses, 0 to 600-Volts: Six of each type and each current rating installed.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. The listing of specific Manufacturers does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed are not relieved from meeting these specifications in their entirety.

2.2 ALTERNATOR

A. Used in control panels where two loads are required to alternate to provide equal run time on the loads;
B. The alternating action is initiated by a control switch, which is common with one side of the control voltage;
C. The output contacts will change states each time the control switch is opened, thus alternating the two loads.
D. Acceptable Alternator Manufacturer's:
   1. MARSH BELLOFRAM®
      ATC DIVERSIFIED ELECTRONICS
      www.marshbellofram.com
      Part No. ARA-120-ACA, where
      AR = Alternating Relay;
      A = Standard Duplexor;
      120 = 120VAC/DC Control Voltage;
      A = VAC or VAC/DC Type;
      C = DPDT (Cross Wired) Contacts;
      A = "A" Lexan® Dust Cover Enclosure;
   2. MOTOR PROTECTION ELECTRONICS, INC.
      www.mpelectronics.com
      Part No. 008-120-13, where
      008 = Alternator product Type;
      120 = 120VAC operating Voltage;
      13 = Relay Base Wiring;

2.3 ANTI-SEIZE/ANTI-CORROSION (COPPER) COMPOUND

A. Copper anti-seize, anti-corrosion compound shall be applied to the threads of all bolts & screws prior to installation;
B. The anti-seize, anti-corrosion compound shall be appropriate to the hardware material being assembled;
C. Use on all types of threaded connections, bushings, keyways, press fits, etc. to protect against seizure, heat freeze, galling, rust and corrosion;
D. Acceptable Anti-Seize/Anti-Corrosion (Copper) Manufacturer's;
   1. CRC® INDUSTRIES, INC.
      www.crcindustries.com

Sta-Lube Copper Anti-Seize;
2. HENKEL CORPORATION
www.loctite.com
LOCTITE® C5-A®;
3. JET LUBE®
www.jetlube.com
KOPR-KOTE®;
4. PERMATEX®, A Division of ITW
www.permatex.com
Copper Anti-Seize;

2.4 BLOCKS, FUSE AND FUSES, 0 TO 600-VOLTS

A. Current-limiting, with 200,000-ampere Root Mean Square (RMS) interrupting rating; Provide to fit mountings specified with switches and features to reject Class H fuses;
B. Motor & Transformer Circuits, 0 to 250-Volts and 0 to 600-Volts - Amperage: 0 to 600; UL 198E, Class RK-1, dual element, with time delay;
C. Feeder and Service Circuits, 0 to 250-Volts and 0 to 600-Volts - Amperage: 0 to 600; UL 198E, Class RK-1, dual element, with time delay;
D. Feeder and Service Circuits, 0 to 600-Volts – Amperage 601 to 6,000-Volts; UL 198C, Class L, double O-rings and silver links;
E. Control circuit specifics;
F. Acceptable Blocks, Fuse and Fuses, 0 to 600-Volts Manufacturers
1. COOPER BUSSMANN®
www.bussmann.com
2. LITTELFUSE®
www.littelfuse.com
3. MERSEN USA
www.mersen.com

2.5 BLOCKS, POWER DISTRIBUTION & SPLICE

A. Power distribution blocks (PDBs);
B. Short-circuit current rated (SCCR);
C. UL1953 Listed;
D. Acceptable Blocks, Power Distribution & Splice Manufacturers
1. COOPER INDUSTRIES
www.cooperbussmann.com
2. BUSSMAN® Series PDBFS;
3. MARATHON SPECIAL PRODUCTS, INC.
www.marathonsp.com
Enclosed Power Blocks –
EPB Series;
4. MERSEN USA
www.mersen.com
Finger-Safe Power Distribution Blocks;
5. ROCKWELL AUTOMATION
www.ab.com
Bulletin 1492 Power Distribution Terminal Blocks;

2.6 BLOCKS, TERMINAL COMPRESSION CLAMP

A. Includes Blocks, End Sections, Jumpers, Stops, Markers, etc.; UL Listed;

B. Acceptable Blocks, Terminal Compression Clamp Manufacturers

1. MARATHON SPECIAL PRODUCTS, INC.
   www.marathonsp.com
   MIK10 and MIW16 DIN Rail Terminal Blocks and Accessories;
2. PHOENIX CONTACT
   www.phoenixcon.com
   Control: Type UK10;
   4-20mA: Type UK5-MTK-P/P;
   Ground Shields: Type USLKGIO;
   Ground Signal Shields: Type UKIO;
   Ground: Type USLKG6N;
3. ROCKWELL AUTOMATION
   www.ab.com
   Allen-Bradley IEC Screw-Type Terminal Blocks (J-Line);
4. SIEMENS INDUSTRY
   www.sea.siemens.com
   ALPHA FIX 8WA and 8WH Terminals with Screw Connection
5. WEIDMULLER
   www.weidmuller.com
   Type W-Series Clamping Yoke Screw Connection;

2.7 BOXES, JUNCTION AND PULL

A. Concrete

1. Box: Reinforced, cast concrete;
2. Application appropriate: either Pedestrian or Traffic Rated;
3. Cover: Cast iron;
4. Cover marking: Marked ELECTRIC, GROUND TEST WELL, TELEPHONE, FIBER, CABLE, etc.;

B. Acceptable Concrete Boxes, Junction and Pull Manufacturers

1. CONCAST INC.
   www.concastinc.com
   Fibercrete®;
2. OLDCASTLE PRECAST®
   www.brooksproducts.net
   BROOKS PRODUCTS;
3. City Preapproved Equal

C. Cast Metal

1. Surface-mounted, Flush-mounted, Sidewalk-boxes, Aboveground Pull-N-Splice Boxes and Aboveground Pull Boxes for Non-hazardous (weatherproof, rainproof, watertight NEMA 4, submersible, dust-tight) and Hazardous (NEMA 7 or 9);
2. Box: Cast metal box;
3. Cover: Cast metal cover;
4. Cover marking: Marked ELECTRIC, GROUND TEST WELL, TELEPHONE, FIBER, CABLE, etc.;

D. Acceptable Cast Metal Boxes, Junction and Pull Manufacturers
   1. COOPER INDUSTRIES
      www.crouse-hinds.com
      CROUSE-HINDS®
      Metallic Enclosures –
      W Series; and RS, RSM and RSS Junction Boxes;
   2. EGS ELECTRICAL GROUP
      www.o-zgedney.com
      O-Z/GEDNEY
      Type YG Cast Iron Junction Boxes;
   3. City Preapproved Equal
E. Stainless Steel
   1. NEMA 4X: Type 316 stainless steel (Continuous-hinge with clamps (bolted or screwed) covers with gaskets;
   2. If used for a terminal junction box, provide terminal strips or terminal blocks with a separate connection point for each conductor entering or leaving the box. Also, provide a minimum of 25% spare terminal points;
   3. ALL NEMA 4X Large (≥24-inch Height x 20-inch Wide) Wall-Mount shall have continuous-hinge with 3-Point Latch;
F. Acceptable Stainless Steel Boxes, Junction and Pull Manufacturers
   1. PENTAIR TECHNICAL PRODUCTS
      www.hoffmanonline.com
      HOFFMAN® Stainless Steel Continuous Hinge Type 4X CHNFSS Junction Boxes
      Continuous Hinge with 3-Point Latch, Type 4X SSLP3PT Enclosures
   2. RITTAL CORP.
      www.rittal.com
      NEMA 4X Junction Boxes;
   3. City Preapproved Equal
G. Non-Metallic (Non-Hazardous and Hazardous)
   1. Aboveground Enclosures (i.e. Pull Box, Junction Box, Splice Box) –
   2. Underground Enclosures (i.e. Pull Box, Junction Box, Hand Hole, Splice Box) - Fiberglass/Polymer Concrete:
      a. Lightweight;
      b. Designed for Tier 8 (12,000lbs) applications;
      c. Flared design provides added work space for easier conduit management;
      d. Minimum 18” Depth;
      e. Bolted Cover;
      f. Cover Marking – as required (i.e. ELECTRIC, CONTROL, FIBER);
H. Non-Metallic (Non-Hazardous and Hazardous) Boxes, Junction and Pull Manufacturers
   1. COOPER INDUSTRIES
      www.crouse-hinds.com
      CROUSE-HINDS®
      TBF/TBP Series N Glass-fiber Reinforced Polyester Enclosures;
      Wall Mount & Large Fiberglass Enclosure Series

2. PENTAIR TECHNICAL PRODUCTS
   www.hoffmanonline.com
   HOFFMAN®
   ZONEX® ATEX-Certified, Type 4X;
3. RITTAL CORP.
   www.rittal.com
   ATEX Plastic Enclosures;
4. HIGHLINE PRODUCTS
   www.highlineproducts.com
   Composite Hand hole Assembly
   CHA Series;
5. HUBBELL® POWER SYSTEMS
   www.hubbellpowersystems.com
   QUAZITE® Below Ground Flared CDR Style;
6. City Preapproved Equal

2.8 BOXES, OUTLET AND DEVICE

A. Cast Metal
   1. Cast ferrous metal box;
   2. Suitable for use in wet locations when used with gasket and flat blank covers;
   3. Green ground screw located on the flange of the box for easy ground wire termination and is standard on boxes;
   4. Cast mounting lugs standard;
   5. Tapered threaded hubs (NPT) with integral bushing;
   6. Available as shallow (FS) or deep (FD) configuration;
   7. Heavy duty, gasketed, weatherproof, cast ferrous metal cover (or copper-free aluminum) with stainless steel screws;

B. Acceptable Cast Metal Outlet and Device Box Manufacturers
   1. COOPER INDUSTRIES
      www.crouse-hinds.com
      CROUSE-HINDS®
      Type FS or FD;
   2. EGS ELECTRICAL GROUP
      www.appletonelec.com
      APPLETON®
      Type FS or FD;

C. Aluminum (Copper-free) Hazardous Location

D. Acceptable Aluminum (Copper-free) Hazardous Location Outlet and Device Box Manufacturers
   1. COOPER INDUSTRIES
      www.crouse-hinds.com
      CROUSE-HINDS®
      Condulet® Explosion-proof Conduit Outlet Boxes & Bodies;
   2. EGS ELECTRICAL GROUP
      www.appletonelec.com
      APPLETON®
      Explosion-proof Conduit Outlet Boxes & Bodies;

E. Metal/Aluminum DIN Mountable
   1. DIN mount Surge Protected Dual Outlet for 120VAC, 15A Service;
F. Acceptable Metal/Aluminum DIN Mountable Outlet and Device Box Manufacturers
   1. HUBBELL® INC.
      www.hubbell-wiring.com
      Part No. DRUBTVSS15;
   2. PHOENIX CONTACT
      www.phoenixcon.com
      EM-DUO-120/15/SPD
      Part No. 56 01 28 3;
G. Non-Metallic
   1. Box: PVC;
   2. Cover: PVC, weatherproof, with stainless steel screws;
H. Acceptable Non-Metallic Outlet and Device Box Manufacturers
   1. CARLON®
      www.carlon.com
      Type FS or FD Switch Boxes
      with Type E98 or E96 covers;
   2. City Preapproved Equal

2.9 BUFFER MODULE

A. With short-term power failures, the load current can be backed up without interruption via the buffer module in combination with the power supply. The buffer module is connected in parallel to the output of the power supply; Used in ALL PLC Panels in UPS Circuit; UL Listed;
B. Acceptable Buffer Module Manufacturers
   1. SIEMENS INDUSTRY
      www.automation.siemens.com
      SITOP Buffer Module,
      Part No. 6EP1 961-3BA00;
   2. NO EQUAL

2.10 CIRCUIT BREAKERS, INDIVIDUAL, 0 TO 600-VOLTS

A. Molded case circuit breakers (MCCB) shall provide circuit overcurrent protection with inverse time and instantaneous tripping characteristics;
B. All circuit breakers shall be UL Listed 489 listed for use at location of installation;
C. Conform to applicable requirements of NEMA Standard Publication No. AB1;
D. Meet appropriate classifications of Federal Specifications W C 375B/Gen.;
E. Minimum Interrupt Rating: As shown on the Contract Drawings or as required;
F. Thermal-magnetic, quick-make, quick-break, indicating type, showing ON/OFF and TRIPPED indicating positions of the operating handle;
G. Suitable for use with 167 °F (75 °C) wire at full NFPA® 70, 167 °F (75 °C) ampacity;
H. Locking: Provisions for padlocking handle;

I. Multi-pole breakers shall automatically open all poles when an overload occurs on one-pole; Do not provide single-pole circuit breakers with handle ties where multi-pole circuit breakers are shown;

J. Enclosure: NEMA 250, Type 12, Industrial Use, 4X, Corrosive, unless otherwise shown;

K. Acceptable Circuit Breakers, Individual, 0 to 600-Volts Manufacturers;

1. EATON CORPORATION
   www.eaton.com
   CUTLER-HAMMER®
   Thermal-Magnetic/ Electronic Trip;
2. ROCKWELL AUTOMATION
   www.ab.com
   ALLEN-BRADLEY®
   Thermal-Magnetic/ Electronic Trip;
3. SCHNEIDER ELECTRIC
   www.schneider-electric.us
   SQUARE D®
   Thermal-Magnetic/ Electronic Trip;
4. SIEMENS INDUSTRY
   www.automation.siemens.com
   SENTRON
   HG miniature –
   1-pole, 1A – 5SJ4101-7HG41;
   1-pole, 2A – 5SJ4102-7HG41;
   1-pole, 5A – 5SJ4111-7HG41;
   2-pole, 1A – 5SJ4201-7HG41;
   SENTRON
   Thermal-Magnetic/ Electronic Trip;

2.11 CONTACTOR, MECHANICAL (A.K.A. LIGHTING CONTACTOR)

A. 3-pole; AC Lighting contactors do not change state and disconnect power from the load during a loss of control power; the operating coil is not required to be continuously energized;

B. Acceptable Contactor, Mechanical (a.k.a. Lighting Contactor) Manufacturers

1. ROCKWELL AUTOMATION
   www.ab.com
   ALLEN-BRADLEY®
   Bulletin 500LC - Mechanically Held Multi-Pole Lighting Contactors;
2. SIEMENS INDUSTRY
   www.automation.siemens.com
   Mechanically Held Contactors, Class CLM with 120VAC/60-Hertz coil;

2.12 CONTACTOR, VACUUM

A. Electrically operated, mechanically held;

A. Main Contacts: Power driven in one direction with gravity dropout, Silver alloy with wiping action and arc quenchers, Continuous-duty, rated 30A, 600-volt, Three-pole;

B. Control: Two-wire; One NO and one NC auxiliary contacts rated 10A at 480-volt;
C. Enclosure: NEMA 250, Type 12;
D. Acceptable Contactor, Vacuum Manufacturers;
1. EATON CORPORATION
www.eaton.com
CUTLER-HAMMER®
A200 Series (NEMA);
2. ROCKWELL AUTOMATION
www.ab.com
ALLEN-BRADLEY®
NEMA Contactors;
3. SIEMENS INDUSTRY
www.automation.siemens.com
SIRIUS
Vacuum Contactors, Class 40;

2.13 COUPLINGS, FLEXIBLE FOR HAZARDOUS LOCATIONS
A. UL Listed;
B. Acceptable Couplings, Flexible for Hazardous Locations Manufacturers
1. EGS ELECTRICAL GROUP
www.o-zgedney.com
O-Z/GEDNEY
Type ECGJH;
2. ADALET,
A SCOTT FETZER CO.
www.adalet.com
PECO Explosion-Proof Flexible Couplings;

2.14 DISCONNECT, SERVICE
A. Used by Lift Stations for Duplex & Triplex outdoor <50HP applications;
B. Complete assembly consists of a thermal magnetic molded case circuit breaker (MCCB), trip unit, NEMA 4X stainless steel enclosure and lugs;
C. Service Disconnect shall be listed as suitable for service entrance application by UL;
D. Acceptable Service Disconnect Manufacturers
1. EATON CORPORATION
www.eaton.com
MCCB, Series C, F-Frame Thermal-Magnetic 125–250A
Part No. HJDP999, where:
HJD = Circuit Breaker/Frame Type;
P = 2 or 3 poles;
999 = Trip unit size;
And
Enclosure
Part No. WJDN250, where:
W = 4/4X Stainless Steel;
JDN = Series C Breaker “HJD”;

225 = 125 to 225A Breaker Range;

2. SIEMENS INDUSTRY
   www.automation.siemens.com
   Enclosed Circuit Breaker,
   Part No. E4XFXD6PB999, where:
   E4X = Type 4X Stainless Steel Enclosure;
   FXD6 = SENTRON Breaker Frame, P = 2 or 3 poles;
   B999 = Trip unit size;

2.15 ENCLOSURES

A. All enclosures shall have a continuous hinge;

B. All enclosures shall have a 3-point latch;

C. All NEMA 12 (dust-tight, intended for indoor use primarily to provide protection against circulating dust, falling dirt and dripping non-corrosive liquids) wall, channel-mounted or free-standing enclosures shall meet the following: Type 316 Stainless Steel (minimum 12 gauge); Continuous Hinge Door(s) with 3-Point Latch(es), Steel Padlocking Handle; 80% minimum of panel interior exposed by doors; Equipped with hand-switch controlled, 40-watt fluorescent light and 120V, 15A duplex utility receptacle, serviced through a dedicated breaker; Each door equipped with a print pocket; Nameplate; Conditioned Interior Location shall be NEMA 12;

D. All NEMA-3R (rain tight, intended for outdoor use primarily to provide protection against rain, sleet and damage from external ice formation) Lift Stations electrical panels shall meet the following: Type 316 Stainless Steel (minimum 12 gauge); Weatherproof with Continuous Hinge Door(s) with 3-Point Latch(es) with dead front panel, separate removable inside panel and Stainless Steel Padlocking Handle;

E. All NEMA 4X (watertight, intended for indoor or outdoor use to provide protection against windblown dust and rain, splashing rain, hose-directed water, and damage from external ice formation) wall, channel-mounted or free-standing enclosures shall meet the following: Type 316 Stainless Steel (minimum 12 gauge); Continuous Hinge Door(s) with 3-Point Latch(es), Stainless Steel Padlocking Handle; 80% minimum of panel interior exposed by doors; Equipped with hand-switch controlled, 26-watt LED, 4000K light and 120V, 15A duplex utility receptacle, serviced through a dedicated breaker; Each door equipped with a print pocket; Nameplate; Non-conditioned Interior Location shall be NEMA 4X; Exterior Location shall be NEMA 4X Full sun shields and be painted white;

F. Acceptable Control Panel Enclosure Manufacturers

1. PENTAIR TECHNICAL PRODUCTS HOFFMAN®
   www.hoffmanonline.com
   NEMA 12
   Concept® Type 12 Steel Wall-Mount Single or Double-Door Enclosures, Continuous Hinge with 3-Point Latch;
   Type 12 Free-Stand Enclosures; Type 12 Floor-Mount Enclosures; all with 3-Point Latches;
   All NEMA-3R
   NEMA 4X

Stainless Steel Wall-Mount Single or Double-Door Enclosures, Continuous Hinge with 3-Point Latch; Or
Stainless Steel Free-Standing Single or Dual Access Enclosures with 3-Point Latches;

2. RITTAL CORP.
www.rittal.com
NEMA 12
Compact AE Single or Double Door Enclosures, Continuous Hinge with 3-point Latch; or
TS 8 Baying Systems;
All NEMA-3R;
NEMA 4X
WM Wall-mount Enclosures with Accessory Part No. WMLHKLS6 – 8018691 L Handle for WM 3 Point Latch, Pad-lockable, Stainless Steel 316L;

2.16 ENCLOSURES, ACCESSORIES

A. Control Panel Enclosure Temperature/Humidity Controls;
   1. Properly sized and selected to meet and maintain all requirements;
B. Acceptable Control Panel Enclosure Temperature/Humidity Control Manufacturers
   1. PENTAIR TECHNICAL PRODUCTS HOFFMAN®
      www.hoffmanonline.com
      Thermal Management Products Corrosive/Outdoor Series CR29
   2. RITTAL CORP.
      www.rittal.com
      System Climate Control Products;
   3. PFANNENBERG INCORPORATED
      www.pfannenbergusa.com
      Stainless Steel (316) / Washdown 4/4X Cooling Units;
C. Control Panel Enclosure Corrosion Inhibiting Vapor Capsules
   1. Vapor capsules emit powerful corrosion inhibiting molecules into an enclosure that settle on metal surfaces and protect them from corrosion;
D. Acceptable Control Panel Enclosure Corrosion Inhibiting Vapor Capsule Manufacturers
   1. PENTAIR TECHNICAL PRODUCTS HOFFMAN®
      www.hoffmanonline.com
      Industrial Corrosion Inhibitors,
      Part No. A-HCIxxxx;
   2. NORTHERN TECHNOLOGIES INT'L CORP.
      www.ntic.com
      Part No. Zerust® ICT® VCx-x;
   3. City Preapproved Equal
E. Control Panel Enclosure Corrosion Inhibitor Emitter
   1. Emitters are unique devices designed to provide corrosion protection for metal components and parts enclosed in non-ventilated control boxes, cabinetry or tool boxes. These devices emit vapors, which

deposit a molecular layer on internal metal surfaces to protect critical, complex and expensive electronic equipment during operation, shipping or storage. Provides long-term protection against corrosion even in the presence of adverse conditions including salt, moisture, airborne contaminants, H2S, SO2, NH3 and others;

F. Acceptable Control Panel Enclosure Corrosion Inhibitor Emitter Manufacturers
   1. PENTAIR TECHNICAL PRODUCTS HOFFMAN®
      www.hoffmanonline.com
      Industrial Corrosion Inhibitors,
      Part No. A-HC15E;
   2. CORTEC® CORPORATION
      www.cortecvci.com
      Vapor phase Corrosion Inhibitors,
      Part No. VpCI-111;
   3. City Preapproved Equal

G. Control Panel Enclosure Combination Drain/Breather
   1. This device provides ventilation to minimize condensation; drain accumulated condensate;

H. Acceptable Control Panel Enclosure ½-inch Combination Drain/Breather Manufacturers
   1. COOPER
      www.crouse-hinds.com
      CROUSE-HINDS®
      Part No. ECD18;
      Breather Only, Part No. ECD13;
      Drain Only, Part No. ECD11;
   2. EGS ELECTRICAL GROUP
      www.appletonelec.com
      APPLETON®
      Part No. Type DB;
      Breather Only, Part No. BRT4X;
      Drain Only, Part No. ECD50B4X;
   3. PENTAIR TECHNICAL PRODUCTS HOFFMAN®
      www.hoffmanonline.com
      H2OMIT® Stainless Steel Vent Drain, Type 4X,
      Part No. AVDR4SS4;
      Stainless Steel Pressure Compensation Device, Type 4X,
      Part No. APCDSS6;

I. Control Panel Enclosure LED Lighting Fixtures
   1. All control panels shall include a lighting fixture for each door;

J. Acceptable Control Panel Enclosure LED Lighting Fixtures Manufacturers
   1. PENTAIR TECHNICAL PRODUCTS HOFFMAN®
      www.hoffmanonline.com
      PANELITE™ LED Enclosure Light, Part No. LED24V15;
   2. RITTAL CORP.
      www.rittal.com

10/20/30/40-LED System Lights
Part No. 4140810, 4140820, 4140830, or 4140840;

K. Control Panel Enclosure Window Kits
   1. ABC

L. Acceptable Control Panel Enclosure Window Kit Manufacturers
   1. CARLON®
      www.carlon.com
      Circuit Safe® NEMA 4X Rated Window Kits;
   2. FIBOX ENCLOSURES
      www.fiboxusa.com
      Inspection Windows or
      Instrument Protection Windows;
   3. City Preapproved Equal

M. Control Panel Enclosure Disconnect, Door Mounted
   1. UL Listed;

N. Acceptable Control Panel Enclosure Disconnect, Door Mounted Manufacturers
   1. SIEMENS INDUSTRY
      www.sea.siemens.com
      Max-Flex™ Flange Mounted Variable Depth Operators;
   2. City Preapproved Equal

2.17 ENCLOSURES, PAD-MOUNT ELECTRICAL

A. Construction: 12 gauge mild steel or aluminum construction; stainless steel available); Type 316 stainless steel hinges, padlock hasp and penta-head bolt latch; Panels available in off-set or in-line configuration and offered in stainless steel, mild steel and galvanneal;

B. Finish: Munsell green 7GY3.29/1.5 polyester powder finish inside and out over phosphatized surfaces; Mounting panels have white polyester powder paint over phosphatized surfaces;

C. Industry Standards: ANSI C57.12.28 Pad-Mounted Equipment Enclosure Integrity;

D. Standard Offering Includes: Choice of single- or three-phase enclosures; Interlocked recessed penta-head latch/padlock provision for tamper resistance; Self-engaging stop to hold cover in open position; Two stops provided if B dimension is greater than or equal to 42 inches; Ground nut provision for each phase; 5/8-11 threaded lifting provisions;

E. Acceptable Enclosures, Pad-Mount Electrical Manufacturers
   1. DURHAM COMPANY
      www.durhamcompany.com
      Pad-Mount Enclosures;
   2. PENTAIR TECHNICAL PRODUCTS
      www.hoffmanonline.com
      HOFFMAN® Utility Junction (UJ) Sectionalizing Enclosures

2.18 GROUNDING BARS

A. Acceptable Grounding Bars Manufacturers
   1. EATON CORPORATION

www.eaton.com
CUTLER-HAMMER®
Part No. GBKxx (where xx = 05, 10, 13, 14, 21 terminals) - Ground Bar Kits;

2. ILSCO
www.ilsco.com
D167 Ground Bars,
Part No. D167-x (where x = 4, 6, 8, 10, 12, and 14 terminals);

3. SCHNEIDER ELECTRIC
www.schneider-electric.us
SQUARE D®
Part No. PKxGTA (where x = 7, 9, 12,15, 18, 23, 27 terminals) Load Center Ground Bar Assembly;

4. SIEMENS INDUSTRY
www.sea.siemens.com
ECGB Series
5, 10, 14, or 20 Position Kits;

2.19 MECHANICAL INTERLOCKS

A. Prevent Paralleling of Lines;

B. Acceptable Mechanical Interlocks Manufacturers

1. KIRK® KEY INTERLOCK COMPANY
www.kirkkey.com
Original Brass Interlocks;

2. SUPERIOR INTERLOCK CORPORATION
www.superiorinterlock.com
Superior Locking Units;

2.20 METERS, ELAPSED TIME

A. 2-inch Face Diameter Cut-out, Semi-flush panel mounting, NEMA 4X;

B. Synchronous motor drive;

C. 0 to 99,999.9 hours (6-digit), non-reset type;

D. Acceptable Meters, Elapsed Time Manufacturers;

1. ENM COUNTING INSTRUMENTS
www.enmco.com
T40 3-Hole Quartz DC Hour Meter;
T50 3-Hole Quartz AC Hour Meter;

2. GENERAL ELECTRIC
www.geindustrial.com
Type 240, 2-½ -inch Big Look;

3. ELECTRO-METERS manufactures the YOKOGAWA 240 Series ETM
www.electro-meters.com

4. TRUMETER TECHNOLOGIES LTD.
www.trumeter.com
Redington Model 722 (732) Totally Sealed AC (DC) Hour Meter;
TRUMETER acquired REDINGTON COUNTERS, INC. in 8/2011

2.21 MINI-POWER CENTER

The mini-power center shall be comprised of a primary main breaker, an encapsulated dry-type transformer and a panelboard with a secondary main breaker;

A. Furnish and install a single-phase and three-phase general purpose individually mounted mini-power centers of the two-winding type, self-cooled, as specified herein and as shown on the Contract Drawings.
B. All components shall be designed, manufactured and tested in accordance with the latest applicable standards of ANSI and NEMA.
C. Ratings:
    1. kVA and voltage ratings shall be as shown on the Contract Drawings;
    2. Units shall be designed for continuous operation at rated kVA, for 24 hours a day, 365 days a year operation, with normal life expectancy as defined in ANSI C57.96;
    3. Transformer sound levels shall not exceed the following ANSI and NEMA levels for self-cooled ratings:
        a. Up to 9 kVA 40 db;
        b. 10 to 30 kVA 45 db;
        c. 40 to 150kVa 50 db;
D. Construction:
    1. Each mini-power center shall include a primary main breaker, an encapsulated dry-type transformer and a panelboard with secondary main breaker;
    2. Primary main, secondary main and feeder breakers shall be enclosed with a padlockable hinged door;
    3. Mini-power centers shall be suitable for service entrance application;
    4. Insulation Systems -
        a. Transformers shall be insulated with a 185 °C insulation system and rated at 115 °C temperature rise;
        b. Required performance shall be obtained without exceeding the above-indicated temperature rise in a 40 °C maximum ambient, with a 30 °C average over 24-hours;
        c. All insulation materials shall be flame-retardant and shall not support combustion as defined in ASTM Standard Test Method D635;
    5. Core and Coil Assemblies -
        a. Transformer core shall be constructed with high-grade, non-aging, silicon steel with high magnetic permeability, and low hysteresis and eddy current losses. Maximum magnetic flux densities shall be substantially below the saturation point. The transformer core volume shall allow efficient transformer operation at 10% above the nominal tap voltage. The core laminations shall be tightly clamped and compressed. Coils shall be wound of electrical grade aluminum with continuous wound construction;
        b. The core and coil assembly shall be completely encapsulated in a proportioned mixture of resin and aggregate to provide a moisture

proof, shock-resistant seal. The core and coil encapsulation system shall minimize the sound level;

c. The core of the transformer shall be grounded to the enclosure;

d. Provide two (2) 5% FCBN taps;

E. Bus:

1. Secondary bus shall be copper.

F. Wiring/Terminations

1. All interconnecting wiring between the primary breaker and transformer, secondary main breaker and transformer and distribution section shall be factory installed;
2. All transformers shall be equipped with a wiring compartment suitable for conduit entry and large enough to allow convenient wiring;

G. Main Breakers - Each mini-power center shall include a primary main breaker with an interrupting rating of □14 kA at 277/480 volts; and a secondary main breaker with an interrupting rating of 10kA at 120/240 volts, and a panelboard;

H. Feeder Breakers - The secondary distribution section shall use ONLY □bolt-on breakers with 10 kA interrupting capacity;

I. Enclosure

1. The enclosure shall be made of stainless steel and the maximum temperature of the enclosure shall not exceed 90 °C;
2. The enclosure shall be totally enclosed, non-ventilated, NEMA 3R, with lifting eyes;

J. Acceptable Mini-Power Center Manufacturers

1. EATON CORPORATION
   www.eaton.com
   Mini-Power Center;
2. SIEMENS INDUSTRY
   www.automation.siemens.com
   Sentron® Power Zone;
3. **SQUARE D Mini Power Zone**

2.22 MONITORS, PHASE

A. Used to detect and alarm under voltage, phase loss, phase reversal and phase unbalance;

B. Specifications:

1. Proper voltage indication and relay energized;
2. Abnormal condition (Under Voltage, Phase issues) indication and relay de-energized;
3. 200-240V or 425-525V;
4. Delta or Wye
5. 10A Resistive (6A Inductive) @240VAC Output Relay Rating;
6. -40 to 122 °F (-40 to 50 °C) Operating Temperature;
7. UL Listed;

C. Acceptable Monitors, Phase Manufacturers

1. MOTOR PROTECTION ELECTRONICS, INC.
   www.mpelectronics.com
   Part No. 001-VVV-1212, where:

001 = Product Type, Phase Monitor;
VVV = Operating Voltage, 230 or 480VAC;
12 = Relay Type, DPDT;
12 = 12-pin Base;

2. City Preapproved Equal

2.23 MOUNTING RAIL, PRE-PUNCHED DIN RAIL

A. 6.5-feet - 1.37-inch x 0.29-inch x 0.03-inch (2-m – 35-mm x 7.5-mm x 1-mm), Chromated;

B. Acceptable Mounting Rail, Pre-Punched DIN Rail Manufacturers

1. ROCKWELL AUTOMATION
www.ab.com
ALLEN-BRADLEY®
Bulletin 1492,
Part No. 199-DR1;

2. SIEMENS INDUSTRY
www.sea.siemens.com
Part No. 5ST 145;

3. WEIDMULLER
www.weidmuller.com
Part No. 51450;

4. City Preapproved Equal

2.24 POWER SUPPLIES

A. UL Listed; DIN rail mount;

B. Acceptable Power Supply Manufacturers

1. PULS
www.pulspower.com
Mini-Line Single-phase, 2.5A, 30-watt,
Part No. ML30.102;
up to 84% Efficiency;
Mini-Line Single-phase, 2.1A, 100-watt,
Part No. ML100.105;
up to 91.5% Efficiency;
Silver-Line Single-phase, 5A, 240-watt,
Part No. SL10.101;
up to 90.4% Efficiency;

2. SIEMENS INDUSTRY
www.automation.siemens.com
LOGO! Series –
Part No. 6EP1 321-1SH02 1.9A;
Part No. 6EP1 322-1SH02 4.5A;
SITOP Series -
Part No. 6EP1 332-2BA10 2.5A;
Part No. 6EP1 333-2BA01 5A;
Part No. 6EP1 334-2BA01 10A;

3. EMERSON ELECTRIC CO.
SOLA-HD POWER SUPPLIES

www.sola-hevi-duty.com
SCP Series, 2.5A, 30-watt,
Part No. SCP 30S12-DN;
>/=75% Efficiency;
SFL Series, 1.5A, 75-watt,
Part No. SFL1.5-48-100;
+85% Efficiency;
SFL Series, 6A, 300-watt,
Part No. SFL6-48-100;
+85% Efficiency;

2.25 PUSHBUTTONS, INDICATING LIGHTS AND SELECTOR SWITCHES

A. General: 30.5 mm mounting hole; Corrosion Resistant, Water-tight, Oil-tight; Contact Rating: NEMA ICS 2, Type A600, 10A Continuous; LED Illumination ONLY; Lamp colors: ON = Green, FAULT = Red; Pushbutton Color;

B. Acceptable Pushbuttons, Indicating Lights and Selector Switches Manufacturers

1. EATON CORPORATION
www.eaton.com
CUTLER-HAMMER®
Type E-30;
2. ROCKWELL AUTOMATION
www.ab.com
ALLEN-BRADLEY®
Bulletin 800T/H 30.5mm NEMA;
3. SCHNEIDER ELECTRIC
www.schneider-electric.us
SQUARE D® Class 9001, Type SK
For SHUNT TRIP –
SQUARE D®
SS Box - 9001 KYSS1;
Station - 9001 K15;
Contacts - 9001 KA1;
For Guarded E-STOP –
SQUARE D®
SS Box,
Part No. 9001 KYSS100;
PB Operator,
Part No. 9001 KR9P38LRR05H13 (120VAC) or
Part No. 9001 KR9P35LRR05H13 (24VDC);
LED,
Part No. 9001 6508805201;
ESTOP Guard,
Part No. 9001 K685;
4. SIEMENS INDUSTRY
www.automation.siemens.com
Black Max, Class 52;

For Guarded E-STOP –
SS Box,
Part No. P30EMS014;
PB Operator,
Part No. 52PX2GRAY (120VAC) or Part No. 52PE2DRA (24VDC);
Contacts,
Part No. 52BJK (24VDC);
LED,
Part No. 52AEB2 (120VAC) or
Part No. 52AEDB (24VDC);
Legend,
Part No. 52NL16R;
ESTOP Guard,
Part No. SQUARE D 9001K685;

5. KIM CONTROLS
   www.kim-controls.com
   Part No. 1A/SAR3/100MH120/BL-P;

C. Watertight Selector Maintained Switches:
   1. Units shall be heavy-duty, watertight, industrial type selector long lever switches;
   2. Contacts rated for 120VAC at 10A continuous;
   3. NEMA 4X watertight, corrosion-resistant;
   4. 30mm standard size, black field and legend plates with white markings, as indicated;
   5. Operators shall be black knob type;
   6. 2-position 1NO + 1NC; 3-position 2NO + 2NC;
   7. Single hole mounting, accommodating panel thickness from 1/16-inch minimum to ¼-inch maximum;

D. Acceptable Watertight Selector Maintained Switch Manufacturers
   1. EATON CORPORATION
      www.eaton.com
      CUTLER-HAMMER®
      Type E-34;
      2-pos. Part No. E34VFBL1-1X;
      3-pos. Part No. E34VHBL1-2X;
   2. ROCKWELL AUTOMATION
      www.ab.com
      ALLEN-BRADLEY®
      Bulletin 800T,
      2-pos. Part No.800T-H17A;
      3-pos. Part No. 800T-J17A;
   3. SCHNEIDER ELECTRIC
      www.schneider-electric.us
      SQUARE D® Class 9001, Type SK
   4. SIEMENS INDUSTRY
      www.automation.siemens.com
      Black Max, Class 52;

2-pos. Part No. 52SW2AABA1;
3-pos. Part No. 52SW2CABA2;

E. Watertight Illuminated Momentary Lamps/Pushbuttons:
1. Units shall be heavy-duty, watertight, industrial type push-to-test pushbutton;
2. Contacts rated for 120VAC at 10A continuous;
3. NEMA 4X watertight, corrosion-resistant;
4. Screwed-on prismatic lenses in colors as shown;
5. 30mm standard size, black field and legend plates with white markings, as indicated;
6. Integrated LED module;
7. Provide contact arrangements as shown;
8. Single hole mounting, accommodating panel thickness from 1/16-inch minimum to ¼-inch maximum;

F. Watertight Illuminated Momentary Lamp/Pushbutton Manufacturers
1. EATON CORPORATION
www.eaton.com
CUTLER-HAMMER®
Type E34;
Part No. E34FPB297L with
Red Lens Part No. E34V2, or
Green Lens Part No. E34V3;
2. ROCKWELL AUTOMATION
www.ab.com
ALLEN-BRADLEY®
Bulletin 800H;
Red Part No. 800H-QRBH2R;
Green Part No. 800H-QRBH2G;
3. SCHNEIDER ELECTRIC
www.schneider-electric.us
SQUARE D® Class 9001, Type SK
4. SIEMENS INDUSTRY
www.automation.siemens.com
Black Max, Class 52;
Red 120V Part No. 52BT6M2A;
Red 24VDC Part No. 52BT6L2A;
Green 120V Part No. 52BT6M3A;
Green 24VDC Part No. 52BT6L3A;

2.26 RELAYS, CONTROL

A. Variants:
1. Plug-in relays - Standard square base with full featured relay shall include dust cover, LED and mechanical flag indication, push-to-test button and typically a latching hold down door which provides a method of activating the contacts without applying power to the coil; Application specific - Contacts (SPDT, DPDT), Contact Rating (in Amperes), and Coil Voltage (in Volts);
2. Machine-tool relays – Contactor relays with multiple poles (NO, NC);

3. Time-delay relays - These relays combine an internal electronic or pneumatic timer with an electromechanical or solid state output. Single-function and field-programmable multi-function types are offered. Timing modules typically control an external relay that switches the load.

B. Acceptable Relays, Control Manufacturers

1. OMRON
   www.omron.com
   120VAC Coil, SPDT, NO/NC contacts, 10 amp contact rating –Base: Part No. P2RF-05-E
   Relay: Part No. G2R-1-SN-AC120S;
   24VDC Coil, SPDT, NO/NC contacts, 10 amp contact rating – Base: Part No. P2RF-05-E
   Relay: Part No. G2R-1-SN-DC24S;
2. OMRON
   www.omron.com
   Series H3, SSAC type TDM
3. PHOENIX CONTACT
   www.phoenixcon.com
   120VAC Coil, SPDT, NO/NC contacts, 10 amp contact rating – Part No. 5520705;
   24VDC Coil, SPDT, NO/NC contacts, 10 amp contact rating – Part No. 5520695;
4. ROCKWELL AUTOMATION
   www.ab.com
   ALLEN-BRADLEY® Bulletin 700-HB Square Base Relay;
   Bulletin 700-CF Control Relays;
5. SIEMENS INDUSTRY
   www.sea.siemens.com
   SIRIUS 3TX71 Plug-in Relays –
   Relay Base and “Premium” Relay;
   SIRIUS 3RH Contactor 4- and 8-pole Relays;
6. SIEMENS INDUSTRY
   www.sea.siemens.com
   Series 3RP;
7. TYCO ELECTRONICS
   POTTER & BRUMFIELD
   www.tycoelectronics.com
   KUMP Series Panel Plug-in Relay;
8. TYCO ELECTRONICS
   www.tycoelectronics.com
   AGASTAT Series 7000;

2.27 RELAYS, INTRINSICALLY SAFE

A. Reference Section 13315 – Field Instrumentation; UL Listed;

1. REFERENCE
   SECTION 13315
   FIELD INSTRUMENTATION;

INTRINSICALLY SAFE RELAYS FOR HAZARDOUS LOCATIONS

2. NO EQUAL

2.28 STARTERS

A. AC motor starters are used to turn-on and turn-off electric motors and motor-controlled equipment. An electric motor starter applies voltage directly to motor terminals to “start” the motor;

B. NEMA ICS 2, Section 322.08 standard rating, except none smaller than NEMA ICS, Size 3;

C. Horsepower rated at 600 volt, UL labeled for 65,000 amperes with overload protection;

D. Three-phase, Full-Voltage, non-reversing, unless otherwise shown;

E. Rated equal to or greater than the AIC rating of the gear;

F. Solid state electronic overload relay with NEMA Class trip curves;

G. Acceptable Starter Manufacturers;

1. EATON CORPORATION
   www.eaton.com
   Freedom NEMA Series;
   Part No. AN19KN0A5E100;
   where:
   A = Device Type, Starter;
   N = Standard, NEMA;
   1 = Device Assembly Configuration, Non-reversing;
   9 = OLR Type, Starter w/ C440 electronic overload;
   K = Contactor Frame Size, NEMA 3 90A Continuous;
   N = NEMA Enclosure, Open;
   0 = Starter Mounting Option, Horizontal;
   A = AC Coil Suffix, 120-Volt/60-Hertz;
   5E = C440 OLR Designation, Standard feature set - SEL Reset, SEL Class (10A, 10, 20, 30);
   100 = C440 FLA Range, NEMA Size 3 20-100A;

2. ROCKWELL AUTOMATION
   www.ab.com
   ALLEN-BRADLEY® Bulletin 509 Open Type Full Voltage Starter:
   Part No. 509-DOD- A2L-99;
   where:
   509 = Bulletin No., Top-wired contactor;
   D = NEMA Size, 3
   O = NEMA Enclosure Type, No enclosure;
   D = Nominal Coil Voltage, 120VAC/60-Hertz;
   A2L = E1 Plus Solid-State Overload Relay, NEMA Size 3 18...90A Full Load Current Adjustment Range;
   99 = Modifications/Options;

3. SIEMENS INDUSTRY
   www.automation.siemens.com
   ESP200® Heavy Duty Motor Starter with Solid State Overload with Auto/Manual Reset, Class 14;
   Part No. 14GUG32AF;

where:
14 = Class, Across the Line NEMA Motor Starter;
G = Size, 2 1/2 NEMA;
U = Model, Size 00-4, 7&8;
G = Current Range, 25A-100A;
3 = Enclosure Size, 3-poles - 3-phase;
2 = Pilot Control Circuit, suitable for 3-wire control (NO aux. contact incl.);
A = Enclosure Type, Open;
F = Coil, 120V@60Hz;

4. **SQUARE D – NEMA Type S**

2.29 SUPPLEMENTARY PROTECTORS

A. Supplemental protectors provide additional protection along with a branch circuit protection device.
B. Certified to UL 1077;
C. Acceptable Supplementary Protectors Manufacturers;
   1. EATON CORPORATION
      www.eaton.com
      WMZS UL 1077 Supplementary Protectors;
   2. SIEMENS INDUSTRY
      www.automation.siemens.com
      5SY4 UL 1077 Supplementary Protectors

2.30 SWITCHES, DOUBLE-THROW FUSED, 0 TO 600-VOLTS

A. Typically used for switching one load between two power sources;
B. All double-throw fused switches shall be UL Listed;
C. NEMA Standards Publication KS1 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum);
D. NEMA 4X 316 Stainless Steel Enclosure with Stainless Steel Internal/External components;
E. Enclosure cover shall be equipped with a switch to prevent opening with switch in the ON position;
F. Quick-make, quick-break, visible blades, motor rated, load-break, heavy-duty type with external markings clearly indicating ON/OFF positions;
G. Plastic nameplate, affixed to the enclosure without screws, identifying the device/equipment served;
H. Suitable for use with 167 °F (75 °C) wire at full NFPA® 70, 167 °F (75 °C) ampacity;
I. Include power source auxiliary contacts (1 NO, 1 NC) to enable City to monitor status;
J. Acceptable Switches, Double-Throw Fused, 0 to 600-Volts Manufacturers;
   1. EATON CORPORATION
      www.eaton.com
      CUTLER-HAMMER®
      Double-Throw Fused,
      Part No. DTxxxFWKX;
   2. SIEMENS INDUSTRY

www.automation.siemens.com
Type DTF
Double-Throw Fused,
Part No. FxxxSSDTK;

3. **SQUARE D – Double Throw - Fused**

2.31 SWITCHES, DOUBLE-THROW NON-FUSED, 0 TO 600-VOLTS

A. Typically used for switching one load between two power sources;
B. All double-throw non-fused switches shall be UL Listed;
C. NEMA Standards Publication KS1 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum);
D. NEMA 4X 316 Stainless Steel Enclosure with Stainless Steel Internal/External components;
E. Enclosure cover shall be equipped with a switch to prevent opening with switch in the ON position;
F. Quick-make, quick-break, visible blades, motor rated, load-break, heavy-duty type with external markings clearly indicating ON/OFF positions;
G. Plastic nameplate, affixed to the enclosure without screws, identifying the device/equipment served;
H. Suitable for use with 167 °F (75 °C) wire at full NFPA® 70, 167 °F (75 °C) ampacity;
I. Include power source auxiliary contacts (1 NO, 1 NC) to enable City to monitor status;
J. Acceptable Switches, Double-Throw Non-fused, 0 to 600-Volts Manufacturers;
   1. EATON CORPORATION
      www.eaton.com
      CUTLER-HAMMER®
      Double-Throw Un-fused,
      Part No. DTxxxUWKX;
   2. SIEMENS INDUSTRY
      www.automation.siemens.com
      Type DTNF
      Double-Throw Un-fused,
      Part No. DTNFxxxS;
   3. **SQUARE D – Double Throw – Non-fused**

2.32 SWITCHES, SINGLE-THROW FUSED, 0 TO 600-VOLTS

A. Typically used as a means to manually connect or disconnect the load from the source;
B. All single-throw fused switches shall be UL Listed;
C. NEMA Standards Publication KS1 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum);
D. NEMA 4X 316 Stainless Steel Enclosure with Stainless Steel Internal/External components;
E. Enclosure cover shall be equipped with a switch to prevent opening with switch in the ON position;
F. Quick-make, quick-break, visible blades, motor rated, load-break, heavy-

duty type with external markings clearly indicating ON/OFF positions;

G. Plastic nameplate, affixed to the enclosure without screws, identifying the device/equipment served;

H. Suitable for use with 167 °F (75 °C) wire at full NFPA® 70, 167 °F (75 °C) ampacity;

I. Acceptable Switches, Single-Throw Fused, 0 to 600-Volts Manufacturers;

1. EATON CORPORATION
   www.eaton.com
   CUTLER-HAMMER®
   Fused,
   Part No. DHxxxFWK316;
2. EATON CORPORATION
   www.eaton.com
   CUTLER-HAMMER® Fused,
   Part No. DHxxxFWK316; SPD installed, 1 x DEHN #952 307 480VAC lightning/surge; Actuator discrete I/O protectors (See Section 16709).
   Use with 480VAC Electric Motor Actuators at all lift stations;
   Qty 4 DIs – Open & Closed Limit; Auto & Fault Status;
   Qty 2 ROs – Open & Close Commands;
3. EATON CORPORATION
   www.eaton.com
   CUTLER-HAMMER® Fused,
   Part No. DHxxxFWK316; SPD installed, 1 x DEHN #952 307 480VAC lightning/surge; Actuator Profibus DP communication protectors (2 x DEHN #920 300 BXT base & 2 x DEHN #926 270 protector module).
   Use with 480VAC Electric Motor Actuators at all treatment facilities;
4. SIEMENS INDUSTRY
   www.automation.siemens.com
   Type VBII
   Fused,
   Part No. HFxxxSS;
5. SIEMENS INDUSTRY
   www.automation.siemens.com
   Type VBII Fused,
   Part No. HFxxxSS; SPD installed,
   1 x DEHN #952 307 480VAC lightning/surge; Actuator discrete I/O protectors (See Section 16709).
   Use with 480VAC Electric Motor Actuators at all lift stations;
   Qty 4 DIs – Open & Closed Limit; Auto & Fault Status;
   Qty 2 ROs – Open & Close Commands;
6. SIEMENS INDUSTRY
   www.automation.siemens.com
   Type VBII Fused,
   Part No. HFxxxSS; SPD installed,
   1 x DEHN #952 307 480VAC lightning/surge; Actuator Profibus DP communication protectors (2 x DEHN #920 300 BXT base & 2 x DEHN #926 270 protector module).

Use with 480VAC Electric Motor Actuators at all treatment facilities;

7. **SQUARE D – Safety Switch - Fused**

2.33 SWITCHES, SINGLE-THROW NON-FUSED, 0 TO 600-VOLTS

A. Typically used as a means to manually connect or disconnect the load from the source;
B. All single-throw non-fused switches shall be UL Listed;
C. NEMA Standards Publication KS1 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum);
D. NEMA 4X 316 Stainless Steel Enclosure with Stainless Steel Internal/External components;
E. Enclosure cover shall be equipped with a switch to prevent opening with switch in the ON position;
F. Quick-make, quick-break, visible blades, motor rated, load-break, heavy-duty type with external markings clearly indicating ON/OFF positions;
G. Plastic nameplate, affixed to the enclosure without screws, identifying the device/equipment served;
H. Suitable for use with 167 °F (75 °C) wire at full NFPA® 70, 167 °F (75 °C) ampacity;
I. Acceptable Switches, Single-Throw Non-fused, 0 to 600-Volts Manufacturers;
   1. EATON CORPORATION
      www.eaton.com
      CUTLER-HAMMER®
      Unfused,
      Part No. DHxxxUWK316;
   2. EATON CORPORATION
      www.eaton.com
      CUTLER-HAMMER® Unfused,
      Part No. DHxxxUWK316; SPD installed, 1 x DEHN #952 307 480VAC lightning/surge; Actuator discrete I/O protectors (See Section 16709).
      Use with 480VAC Electric Motor Actuators at all lift stations;
      Qty 4 DIs – Open & Closed Limit; Auto & Fault Status;
      Qty 2 ROs – Open & Close Commands;
   3. EATON CORPORATION
      www.eaton.com
      CUTLER-HAMMER® Unfused,
      Part No. DHxxxUWK316; SPD installed, 1 x DEHN #952 307 480VAC lightning/surge; Actuator Profibus DP communication protectors (2 x DEHN #920 300 BXT base & 2 x DEHN #926 270 protector module).
      Use with 480VAC Electric Motor Actuators at all treatment facilities;
   4. SIEMENS INDUSTRY
      www.automation.siemens.com
      Type VBII
      Unfused,
      Part No. HNFxxxSS;
   5. SIEMENS INDUSTRY
      www.automation.siemens.com

Type VBII Unfused,
Part No. HNFxxxSS; SPD installed, 1 x DEHN #952 307 480VAC lightning/surge; Actuator discrete I/O protectors (See Section 16709). Use with 480VAC Electric Motor Actuators at all lift stations;
Qty 4 DIs – Open & Closed Limit; Auto & Fault Status;
Qty 2 ROs – Open & Close Commands;

6. SIEMENS INDUSTRY
www.automation.siemens.com
Type VBII Unfused,
Part No. HNFxxxSS; SPD installed, 1 x DEHN #952 307 480VAC lightning/surge; Actuator Profibus DP communication protectors (2 x DEHN #920 300 BXT base & 2 x DEHN #926 270 protector module). Use with 480VAC Electric Motor Actuators at all treatment facilities;
7. **SQUARE D – Safety Switch – Non-fused**

2.34 TRANSFORMERS, CONTROL POWER

A. Control Power Transformer (CPT) features shall include:
1. CPT for all low voltage control panel applications shall be sized per motor space heater requirements, minimum 500VA;
2. CPTs for Motor Control Center (MCC) applications shall be sized per motor horsepower (i.e. the largest CPT that will fit within the bucket); the minimum shall be provided:
a. 150VA shall be used for less than 25HP;
b. 250VA shall be used for up to100HP;
c. 500VA shall be used for all above 100HP;
3. Two winding, 480VAC primary,120VAC secondary voltage;
4. Three-pole circuit breaker protection for primary;
5. Single-pole circuit breaker protection for secondary;
6. Single-pole circuit breaker protection for motor space heater;
7. Suitable for use with 194 °F (90 °C) wire at full ampacity;
8. UL 506 Listed;

B. Acceptable Transformers, Control Power Manufacturers;
1. EATON CORPORATION
www.eaton.com
CUTLER-HAMMER®
Type MTE;
2. ROCKWELL AUTOMATION
www.ab.com
ALLEN-BRADLEY®
Bulletin 1497B;
3. SIEMENS INDUSTRY
www.sea.siemens.com
Class MT;
4. **SQUARE D – Control Power Transformers**

2.35 TRANSFORMERS, DRY TYPE LIGHTING

A. 480VAC, 3-phase Primary and
1. UL 1561, NEMA ST 20;

2. Self-cooled, two-winding, UL K-4 rated for nonlinear loads;
3. Insulation Class and Temperature Rise: Manufacturer's standard;
4. Core and Coil –
    a. Encapsulated for single-phase units 1/2 to 25 kVA and for three-phase units 3 to 15 kVA;
    b. Thermosetting varnish impregnated for single-phase units 37.5 kVA and above, and for three-phase units 30 kVA and above;
5. Enclosure –
    a. Single-Phase, 3 to 25 kVA: NEMA 250, Type 3R, non-ventilated;
    b. Single-Phase, 37-1/2 kVA and Above: NEMA 250, Type 2, ventilated;
    c. Three-Phase, 3 to 15 kVA: NEMA 250, Type 3R, non-ventilated;
    d. Three-Phase, 30 kVA and Above: NEMA 250, Type 2, ventilated;
    e. Outdoor Transformers: NEMA 250, Type 3R;
6. Wall Bracket: For single-phase units, 15 to 37-1/2 kVA, and for three-phase units, 15 to 30 kVA;
7. Voltage Taps –
    a. Single-Phase, 3 to 10 kVA: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating;
    b. Single-Phase, 15 kVA and Above: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating;
    c. Three-Phase, 3 to 15 kVA: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating;
    d. Three-Phase, 30 kVA and Above: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating;
8. Impedance: 4.5 percent minimum on units 75 kVA and larger;
9. Maximum Sound Level per NEMA ST 20 –
    a. 40 decibels for 0 to 9 kVA;
    b. 45 decibels for 10 to 50 kVA;
    c. 50 decibels for 51 to 150 kVA;
    d. 55 decibels for 151 to 300 kVA;
    e. 60 decibels for 301 to 500 kVA;
10. Vibration Isolators –
    a. Rated for transformer's weight;
    b. Isolation Efficiency: 99 percent, at fundamental frequency of sound emitted by transformer;
    c. Less Than 30 kVA: Isolate entire unit from structure with external vibration isolators;
    d. 30 kVA and Above: Isolate core and coil assembly from transformer enclosure with integral vibration isolator:

B. Acceptable Transformers, Dry Type Lighting Manufacturers
1. EATON CORPORATION
   www.eaton.com
   NEMA Premium® Efficient Transformers;
2. SIEMENS INDUSTRY
   www.sea.siemens.com
   NEMA Premium® Efficient Transformers;

3. **SQUARE D – NEMA Premium Efficiency Transformers**

2.36 WALL SWITCHES

A. Wall switches shall be flush-mounting, quiet type; All switches shall conform to Federal Specification WS-896-E;

B. Single-Pole, Double-Pole, 3-Way, 4-Way, toggle switch, 120/277 VAC, 20A; NEMA WD 1 & 6; UL 20; 10-Year Limited Warranty; Color to be specified by City;

C. Acceptable Single-Pole, Double-Pole, 3-Way, 4-Way, toggle switch Manufacturers

1. COOPER INDUSTRIES
   www.arrowhart.com
   ARROW-HART™ Wiring Devices,
   AC Quiet Toggle Switches,
   Model No. 122x Series;
2. LEVITON
   www.leviton.com
   Heavy Duty AC Toggle Switches,
   Model No. 122x Series;
3. City Preapproved Equal

D. Single-Pole, Double-Pole, 3-Way, key-operated, 120/277VAC, 20A; nickel-plated lock dome, NEMA WD 1 & 6; UL 20; Color to be specified by City;

E. Acceptable Single-Pole, Double-Pole, 3-Way, key-operated Manufacturers

1. COOPER INDUSTRIES
   www.arrowhart.com
   ARROW-HART™ Wiring Devices,
   AC Corbin Type Locking Switches,
   Model No. AH119x Series
2. LEVITON
   www.leviton.com
   Heavy Duty AC Toggle Switches,
   Key Locking Switches,
   Model No. 122x-2KL;
3. City Preapproved Equal

F. Momentary contact, 2-circuit, center off, 120/277VAC, 20A; NEMA WD 1 & 6; UL 20; Color to be specified by City;

G. Acceptable Momentary contact, 2-circuit, center off Manufacturers;

1. COOPER INDUSTRIES
   www.arrowhart.com
   ARROW-HART™ Wiring Devices,
   AC Quiet Toggle Switches,
   Model No. 122x Series;
2. LEVITON
   www.leviton.com
   Heavy Duty AC Toggle Switches,
   Momentary Contact Switches,
   Model No. 1257 Series;
3. City Preapproved Equal

H. Spring Wound Interval Timer Switch, 120/277VAC, 20A;
I. Acceptable Spring Wound Interval Timer Switch Manufacturers
1. INTERMATIC INC.
www.intermatic.com
Spring Wound Interval Timer,
Model No. FF60MHC;
1-HP 125VAC, 50/60-Hz;
2-HP 250VAC, 50/60-Hz;
20A 125VAC, 50/60-Hz;
10A 150VAC, 50/60-Hz;
10A 277VAC, 50/60-Hz;
7A 125VAC, Tungsten;
2. City Preapproved Equal

2.37 STRAIGHT-BLADE RECEPTACLES
A. All receptacles shall conform to Federal Specification WS-596; Straight-blade receptacles shall be of the following types:
B. Single/Duplex Receptacle; 20A, 125VAC, NEMA 5-20R, 1P/2P, 3W, Industrial, Extra Heavy Duty Specification Grade, Straight Blade, Self-Grounding; 10-Year Limited Warranty; Color to be specified by City;
C. Acceptable Single/Duplex Receptacle Manufacturers
1. COOPER INDUSTRIES
www.arrowhart.com
ARROW-HART™ Wiring Devices,
Premium Industrial Grade Receptacles,
Model No. 536x Series;
2. LEVITON
www.leviton.com
Heavy-Duty Industrial Grade Straight Blade Receptacles,
Model No. 536x Series;
3. City Preapproved Equal
D. Weatherproof Cover; Single or Duplex Receptacle Wall-plate, Rain-tight While-In-Use, Thermoplastic, Device Mount, Vertical Extra Deep Self Closing Lid;
E. Acceptable Weatherproof Cover; Single or Duplex Receptacle Wall-plate, Rain-tight While-In-Use Manufacturers
1. LEVITON
www.leviton.com
1-Gang Single/Duplex Device Receptacle Wall-plate, Rain-tight While-In-Use, Thermoplastic, Device Mount, Horizontal Lid – Gray;
Model No. 5978-GY (Single);
Model No. 5996-GY (Duplex);
2. City Preapproved Equal
F. Duplex, Corrosion-Resistant Receptacle; 20A, 125VAC, NEMA 5-20R, 2P, 3W, Industrial, Extra Heavy Duty Specification Grade, Straight Blade, Self-Grounding; 10-Year Limited Warranty; Color to be specified by City;
G. Acceptable Duplex, Corrosion-Resistant Receptacle Manufacturers
1. COOPER INDUSTRIES

www.arrowhart.com
ARROW-HART™ Wiring Devices,
Corrosion Resistant Premium Industrial Grade,
Model No. 5362CR;
Gray or Yellow;

2. LEVITON
www.leviton.com
Heavy-Duty Industrial Grade Straight Blade Receptacles,
Model No. 53CM-62;
Yellow;

3. City Preapproved Equal

H. Ground Fault Circuit Interrupters (GFCI), Duplex, Receptacle; 20A, 125VAC, NEMA 5-20R, 2P, 3W, Industrial, Extra Heavy Duty Specification Grade, Straight Blade, Self-Grounding; Color to be specified by City;

I. Acceptable Ground Fault Circuit Interrupters (GFCI), Duplex, Receptacle Manufacturers

1. COOPER INDUSTRIES
www.arrowhart.com
ARROW-HART™ Wiring Devices,
Weather Resistant GFCI Receptacle,
Model No. WRVGF20;
20A 125VAC, NEMA 5-20R;

2. LEVITON
www.leviton.com
Ground Fault Circuit Interrupters (GFCI),
Model No. W7899-W;
20A, 125VAC, Weather Resistant Smart Lock Pro GFCI,
Monochromatic, wall plate sold separately – White;
2-Year Limited Warranty;

3. HUBBELL® INC.
www.hubbell-wiring.com
Circuit Guard® Heavy Duty Commercial and Hospital Grade GFCI Receptacle with Auto Grounding,
Catalog No. GF15xx
Utility Outlet in A Control Panel Use Only - 15A, 125VAC;

4. City Preapproved Equal

J. Stainless Steel Indoor Wall Plate GFCI Duplex Receptacle;

K. Acceptable Stainless Steel Indoor Wall Plate GFCI Duplex Receptacle Manufacturers

1. COOPER INDUSTRIES
www.arrowhart.com
ARROW-HART™ Wiring Devices,
Stainless Steel Decorator,
Model No. 93401;

2. LEVITON
www.leviton.com
Decora Wall plates,

Model No. 84401-40;
Decora/GFCI Device Decora Wall plate, Standard Size, 302 Stainless Steel, Device Mount, - Stainless Steel;

3. City Preapproved Equal

L. Weatherproof Cover for GFCI Duplex Receptacle;

M. Acceptable Weatherproof Cover for GFCI Duplex Receptacle Manufacturers

1. LEVITON
   www.leviton.com
   1-Gang Single/Duplex Device Receptacle Wall-plate, Rain-tight While-In-Use, Thermoplastic, Device Mount, Horizontal Lid – Gray;
   Model No. 5996-DGY (Duplex);
2. City Preapproved Equal

N. Single Receptacle; 20A, 250VAC, NEMA 6-20R, 2P, 3W, Industrial; Color to be specified by City;

O. Acceptable Single Receptacle Manufacturers

1. COOPER INDUSTRIES
   www.arrowhart.com
   ARROW-HART™ Wiring Devices, Isolated Ground Premium Industrial Grade Receptacles,
   Model No. IG5461;
   20A, 250VAC, NEMA 6-20R;
2. LEVITON
   www.leviton.com
   Wetguard Devices Receptacles,
   Model No. 5461;
   20A, 250VAC, NEMA 6-20R, 2P, 3W, Narrow Body Single Receptacle, Straight Blade, Industrial Grade, Grounding, Corrosion Resistant, Side Wired, Nickel-Plated Brass Strap, - Yellow;
   Lifetime Warranty;
3. City Preapproved Equal

2.38 DEVICE PLATES

A. Plates for flush mounted devices shall be of the required number of gangs for the application involved and shall be 302 (18-8) high nickel stainless steel of the same Manufacturer as the device;

B. Plates for surface mounted device boxes shall be of the same material as the box;

C. C. Acceptable Device Plate Manufacturers

1. COOPER INDUSTRIES
   www.arrowhart.com
   302 (18-8) high nickel stainless steel;
2. LEVITON
   www.leviton.com
   302 (18-8) high nickel stainless steel;
3. City Preapproved Equal

2.39 RECEPTACLES, RJ-45 MODULAR

A. Industrial grade;
B. Acceptable Receptacles, RJ-45 Modular Manufacturers
   1. LEVITON
      www.leviton.com
      DuraPort™ Industrial Outlet Kits;
   2. City Preapproved Equal

2.40 WIRING DUCTS AND COVERS, SLOTTED

A. Used for organizing, routing and concealing wiring in control panels; Light Gray Color;
B. Acceptable Wiring Ducts and Covers, Slotted Manufacturers
   1. PANDUIT® CORP.
      www.panduit.com
      PANDUCT® Type G (Wide Finger Flush Design) and PANELMAX™ DIN Rail;
   2. THOMAS & BETTS
      www.tnb.com
      TY-DUCT™ Wide-Slot;
   3. City Preapproved Equal

2.41 UNINTERRUPTIBLE POWER SUPPLY (UPS), 5KVA AND LARGER

A. UL Listed;
B. Acceptable Uninterruptible Power Supply (UPS), 5kVA and Larger Manufacturers
   1. EATON CORPORATION
      www.powerware.com
      POWERWARE®
      w/ SNMP Network Card
   2. City Preapproved Equal

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install all devices in accordance with the Manufacturer's instructions and the Contract Drawings.
B. Remove temporary lifting angles, lugs and shipping braces. Touch-up damaged paint finishes.
C. Caulk seams, cracks, and openings in outdoor enclosures.

3.2 ADJUSTING AND CLEANING

A. The devices described in this section shall be adjusted accordingly per Manufacturer's recommendations.
B. Clean exposed surfaces using Manufacturer recommended materials and methods.
C. Vacuum all interior spaces.

3.3 TESTING

A. Perform factory and installation tests in accordance with applicable NEC®, NEMA and UL requirements.

3.4 STARTUP SERVICES

A. Engage a factory-authorized service representative to perform startup service.
B. Train City's maintenance personnel on procedures and schedules for energizing and de-energizing, troubleshooting, servicing and maintaining equipment and schedules.
C. Verify that all devices are installed and connected according to the Contract Documents.
D. Verify that electrical control wiring installation complies with Manufacturer's submittal by means of point-to-point continuity testing.
E. Verify that wiring installation complies with requirements in Division 16 Sections.
F. Complete installation and startup checks according to Manufacturer's written instructions.

3.5 WARRANTY

A. Equipment Manufacturer warrants that all goods supplied are free of non-conformities in workmanship and materials for one year from date of Substantial Completion.

3.6 INSTALLATION - TRANSFORMERS, DRY TYPE LIGHTING

A. Set transformers plumb and level.
B. Mount wall-mounted transformers using integral flanges or accessory brackets furnished by the Manufacturer.
C. Ensure that transformer are loaded in a reasonably balanced manner across all three phases.
D. Once the system has been energized, and prior to final commissioning and start-up, measure primary and secondary voltages and adjust the appropriate tap(s);

End of Section

Section 16108

MISCELLANEOUS EQUIPMENT

PART 1 - GENERAL

1.1 SCOPE

A. Furnish and install all miscellaneous devices and equipment as hereinafter specified and/or as shown on the Contract Drawings.

B. Related Work Specified Elsewhere (if included):

1. Division 1 – General Requirements;
2. Division 2 – Site Work;
3. Division 3 – Concrete;
4. Division 11 – Equipment;
5. Division 13 – Special Construction;
6. Division 15 – Mechanical;
7. Division 16 – Electrical;

1.2 REFERENCES

A. All characteristics, definitions, and terminology, except as specifically covered in this Specification, shall be in accordance with the latest revision of the following standards:

1. National Electrical Contractors Association (NECA) National Electrical Installation Standards (NEIS);
2. NECA 1 - Standard Practice of Good Workmanship in Electrical Construction;
3. NECA 409 - Standard for Installing and Maintaining Dry-Type Transformers;
4. National Fire Protection Association® (NFPA®) 70 – National Electrical Code® (NEC®);
5. NFPA® 70E® - Electrical Safety in the Workplace;

1.3 SUBMITTALS

A. Submit shop drawings in accordance with the General Conditions and Section 01420.

B. All submittal documents shall be provided in both hardcopy, bounded in separate three-ring binders, indexed, tabbed with sectional dividers, and no larger than 8½-inch x 11-inch and bookmarked electronic media - Adobe® Acrobat® portable document format. Two sets of hardcopy and two sets of electronic media shall be provided.

C. All drawings shall be provided in both hardcopy, bounded, indexed, and no larger than 11-inch x 17-inch and bookmarked electronic media - Autodesk® AutoCAD® file format AND Adobe® Acrobat® portable document format. Two sets of hardcopy and two sets of electronic media shall be provided.

D. The following information, at a minimum, shall be submitted to the City:

1. Descriptive bulletins;

2. Product data sheets;
3. Master drawing index;
4. Dimensioned front & plan view of the assembly;
5. Schematic diagram;
6. Cable terminal sizes;
7. Component list;
8. Conduit space entry/exit locations;
9. Ratings;
10. Wiring diagrams;
11. Installation information;

1.4 QUALITY ASSURANCE

A. The Manufacturer shall have a minimum of ten (10) years consecutive experience producing similar electrical devices or equipment.
B. The Manufacturer shall be ISO certified.
C. UL Listing Requirements –
   1. "Manufactured in accordance with" is not equivalent to "UL LISTED" and does not meet the intent of this specification;
   2. The miscellaneous devices and/or equipment shall be posted at www.UL.com under the appropriate Category Code. Products without posting at UL.com shall not be approved. To access UL Category Code, click on Certifications of UL's home page. Type the appropriate code into the Category Code search box and click Search.

1.5 DELIVERY, STORAGE AND HANDLING

A. Deliver products and equipment in factory labeled packages that include recommended storage practices placed on the outside of the shipping container.
B. Handling and shipment of the products and equipment shall be in such a manner to prevent internal component damage, breakage, and denting and scoring of the enclosure finish.
C. Store and handle in strict compliance with Manufacturer's instructions and recommendations. Protect from potential damage from weather and construction operations. Store so condensation will not form on or in equipment and if necessary, apply temporary heat where required to obtain suitable service conditions.

PART 2 - PRODUCTS

2.1 BLOCKS, FUSE AND FUSES, 0 TO 600VAC

A. Current-limiting, with 200,000-ampere Root Mean Square (RMS) interrupting rating; Provide to fit mountings specified with switches and features to reject Class H fuses;
   1. Motor & Transformer Circuits, 0 to 250VDC and 0 to 600VAC - Amperage: 0 to 600; UL 198E, Class RK-1, dual element, with time delay;

2. Feeder and Service Circuits, 0 to 250VDC and 0 to 600VAC - Amperage: 0 to 600; UL 198E, Class RK-1, dual element, with time delay;
3. Feeder and Service Circuits, 0 to 600VDC – Amperage 601 to 6,000VAC; UL 198C, Class L, double O-rings and silver links;
4. Control circuit specifics;

B. Acceptable Blocks, Fuse and Fuses, 0 to 600VAC Manufacturers
1. COOPER BUSSMANN®
www.bussmann.com
2. LITTELFUSE®
www.littelfuse.com
3. MERSEN USA
www.mersen.com

2.2 MINI-POWER CENTER

A. Furnish and install a single-phase and three-phase general purpose individually mounted mini-power centers of the two-winding type, self-cooled, as specified herein and as shown on the Contract Drawings.
B. All components shall be designed, manufactured and tested in accordance with the latest applicable standards of ANSI and NEMA.
C. Ratings:
1. kVA and voltage ratings shall be as shown on the Contract Drawings;
2. Units shall be designed for continuous operation at rated kVA, for 24 hours a day, 365 days a year operation, with normal life expectancy as defined in ANSI C57.96;
3. Transformer sound levels shall not exceed the following ANSI and NEMA levels for self-cooled ratings:
a. Up to 9 kVA 40 db;
b. 10 to 30 kVA 45 db;
c. 40 to 150kVa 50 db;

D. Construction:
1. Each mini-power center shall include a primary main breaker, an encapsulated dry-type transformer and a panelboard with secondary main breaker;
2. Primary main, secondary main and feeder breakers shall be enclosed with a padlockable hinged door;
3. Mini-power centers shall be suitable for service entrance application;
4. Insulation Systems -
a. Transformers shall be insulated with a 185 °C insulation system and rated at 115 °C temperature rise;
b. Required performance shall be obtained without exceeding the above-indicated temperature rise in a 40 °C maximum ambient, with a 30 °C average over 24-hours;
c. All insulation materials shall be flame-retardant and shall not support combustion as defined in ASTM Standard Test Method D635;

5. Core and Coil Assemblies -
    a. Transformer core shall be constructed with high-grade, non-aging, silicon steel with high magnetic permeability, and low hysteresis and eddy current losses. Maximum magnetic flux densities shall be substantially below the saturation point. The transformer core volume shall allow efficient transformer operation at 10% above the nominal tap voltage. The core laminations shall be tightly clamped and compressed. Coils shall be wound of electrical grade aluminum with continuous wound construction;
    b. The core and coil assembly shall be completely encapsulated in a proportioned mixture of resin and aggregate to provide a moisture proof, shock-resistant seal. The core and coil encapsulation system shall minimize the sound level;
    c. The core of the transformer shall be grounded to the enclosure;
    d. Provide two (2) 5% FCBN taps;

E. Bus:
1. Secondary bus shall be copper.

F. Wiring/Terminations
1. All interconnecting wiring between the primary breaker and transformer, secondary main breaker and transformer and distribution section shall be factory installed;
2. All transformers shall be equipped with a wiring compartment suitable for conduit entry and large enough to allow convenient wiring;

G. Main Breakers
1. Each mini-power center shall include a primary main breaker with an interrupting rating of 14 kA at 277/480 volts; and a secondary main breaker with an interrupting rating of 10kA at 120/240 volts, and a panelboard;

H. Feeder Breakers
1. The secondary distribution section shall use ONLY bolt-on breakers with 10 kA interrupting capacity;

I. Enclosure
1. The enclosure shall be made of heavy-gauge steel and the maximum temperature of the enclosure shall not exceed 90 °C;
2. The enclosure shall be totally enclosed, non-ventilated, NEMA 3R, with lifting eyes;

J. Acceptable Mini-Power Center Manufacturers
1. EATON CORPORATION
   www.eaton.com
   See Section 16160 Panelboard and 16050 Basic Electrical Materials and Methods for specific product offerings;
2. SIEMENS INDUSTRY
   www.automation.siemens.com
   See Section 16160 Panelboard and 16050 Basic Electrical Materials and Methods for specific product offerings;
3. **SQUARE D – Mini Power Zone**

2.3 SWITCHES, SINGLE-THROW FUSED, 0 TO 600VAC

A. Stainless Steel (Internal & External); UL Listed; NEMA Standards Publication KS1 - Enclosed and Miscellaneous Distribution Equipment Switches (600VAC Maximum); Quick-make, quick-break, visible blades, motor rated, load-break, heavy-duty type with external markings clearly indicating ON/OFF positions; Suitable for use with 75 °C wire at full NFPA® 70, 75 °C ampacity; Enclosure: NEMA 4X 316 Stainless Steel; Enclosure cover shall be equipped with a switch to prevent opening with switch in the ON position; Plastic nameplate, affixed to the enclosure without screws, identifying the device/equipment served;

B. Acceptable Switches, Single-Throw Fused, 0 to 600VAC Manufacturers

1. EATON CORPORATION
   www.eaton.com
   CUTLER-HAMMER® Fused,
   Part No. DHxxxFWK316;
2. EATON CORPORATION
   www.eaton.com
   CUTLER-HAMMER® Fused,
   Part No. DHxxxFWK316; SPD installed, 1 x DEHN #952 307 480VAC lightning/surge; Actuator discrete I/O protectors (See Section 16709).
3. EATON CORPORATION
   www.eaton.com
   CUTLER-HAMMER® Fused,
   Part No. DHxxxFWK316; SPD installed, 1 x DEHN #952 307 480VAC lightning/surge; Actuator Profibus DP communication protectors (2 x DEHN #920 300 BXT base & 2 x DEHN #926 270 protector module).
4. SIEMENS INDUSTRY
   www.automation.siemens.com
   Type VBII Fused,
   Part No. HFxxxSS;
5. SIEMENS INDUSTRY
   www.automation.siemens.com
   Type VBII Fused,
   Part No. HFxxxSS; SPD installed,
   1 x DEHN #952 307 480VAC lightning/surge; Actuator discrete I/O protectors (See Section 16709).
6. SIEMENS INDUSTRY
   www.automation.siemens.com
   Type VBII Fused,
   Part No. HFxxxSS; SPD installed,
   1 x DEHN #952 307 480VAC lightning/surge; Actuator Profibus DP communication protectors (2 x DEHN #920 300 BXT base & 2 x DEHN #926 270 protector module).
7. **SQUARE D – Single Throw - Fused**

2.4 SWITCHES, SINGLE-THROW NON-FUSED, 0 TO 600VAC

A. Typically used as a means to manually connect or disconnect the load from

the source; Stainless Steel (Internal & External) - UL Listed; NEMA Standards Publication KS1 - Enclosed and Miscellaneous Distribution Equipment Switches (600VAC Maximum); Quick-make, quick-break, visible blades, motor rated, load-break, heavy-duty type with external markings clearly indicating ON/OFF positions; Suitable for use with 75 °C wire at full NFPA 70, 75 °C ampacity; Enclosure: NEMA 4X 316 Stainless Steel; Enclosure cover shall be equipped with a switch to prevent opening with switch in the ON position; Plastic nameplate, affixed to the enclosure without screws, identifying the device/equipment served;

B. Acceptable Switches, Single-Throw Non-fused, 0 to 600VAC Manufacturers
   1. EATON CORPORATION
      www.eaton.com
      CUTLER-HAMMER® Unfused,
      Part No. DHxxxUWK316;
   2. EATON CORPORATION
      www.eaton.com
      CUTLER-HAMMER® Unfused,
      Part No. DHxxxUWK316; SPD installed, 1 x DEHN #952 307 480VAC lightning/surge; Actuator discrete I/O protectors (See Section 16709).
   3. EATON CORPORATION
      www.eaton.com
      CUTLER-HAMMER® Unfused,
      Part No. DHxxxUWK316; SPD installed, 1 x DEHN #952 307 480VAC lightning/surge; Actuator Profibus DP communication protectors (2 x DEHN #920 300 BXT base & 2 x DEHN #926 270 protector module).
   4. SIEMENS INDUSTRY
      www.automation.siemens.com
      Type VBII Unfused,
      Part No. HNFxxxSS;
   5. SIEMENS INDUSTRY
      www.automation.siemens.com
      Type VBII Unfused,
      Part No. HNFxxxSS; SPD installed, 1 x DEHN #952 307 480VAC lightning/surge; Actuator discrete I/O protectors (See Section 16709).
   6. SIEMENS INDUSTRY
      www.automation.siemens.com
      Type VBII Unfused,
      Part No. HNFxxxSS; SPD installed, 1 x DEHN #952 307 480VAC lightning/surge; Actuator Profibus DP communication protectors (2 x DEHN #920 300 BXT base & 2 x DEHN #926 270 protector module).
   7. **SQUARE D – Single Throw – Non-fused**

2.5 TRANSFORMERS, DRY TYPE LIGHTING

A. 480VAC, 3-phase Primary and
   1. UL 1561, NEMA ST 20;
   2. Self-cooled, two-winding, UL K-4 rated for nonlinear loads;
   3. Insulation Class and Temperature Rise: Manufacturer's standard;

4. Core and Coil –
   a. Encapsulated for single-phase units 1/2 to 25 kVA and for three-phase units 3 to 15 kVA;
   b. Thermosetting varnish impregnated for single-phase units 37.5 kVA and above, and for three-phase units 30 kVA and above;
   c. Single-Phase, 3 to 25 kVA: NEMA 250, Type 3R, non-ventilated;
   d. Single-Phase, 37-1/2 kVA and Above: NEMA 250, Type 2, ventilated;
   e. Three-Phase, 3 to 15 kVA: NEMA 250, Type 3R, non-ventilated;
   f. Three-Phase, 30 kVA and Above: NEMA 250, Type 2, ventilated;
   g. Outdoor Transformers: NEMA 250, Type 3R;
   h. Single-Phase, 3 to 10 kVA: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating;
   i. Single-Phase, 15 kVA and Above: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating;
   j. Three-Phase, 3 to 15 kVA: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating;
   k. Three-Phase, 30 kVA and Above: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating;
   l. 40 decibels for 0 to 9 kVA;
   m. 45 decibels for 10 to 50 kVA;
   n. 50 decibels for 51 to 150 kVA;
   o. 55 decibels for 151 to 300 kVA;
   p. 60 decibels for 301 to 500 kVA;
   q. Rated for transformer's weight;
   r. Isolation Efficiency: 99 percent, at fundamental frequency of sound emitted by transformer;
   s. Less Than 30 kVA: Isolate entire unit from structure with external vibration isolators;
   t. 30 kVA and Above: Isolate core and coil assembly from transformer enclosure with integral vibration isolator:

B. Acceptable Transformers, Dry Type Lighting Manufacturers
   1. EATON CORPORATION
      www.eaton.com
      NEMA Premium® Efficient Transformers;
   2. SIEMENS INDUSTRY
      www.sea.siemens.com
      NEMA Premium® Efficient Transformers;
   3. **SQUARE D – NEMA Premium Efficiency Transformers**

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install all devices in accordance with the Manufacturer’s instructions and the Contract Drawings.
B. Remove temporary lifting angles, lugs, and shipping braces. Touch-up damaged paint finishes.
C. Caulk seams, cracks, and openings in outdoor enclosures.

3.2 ADJUSTING AND CLEANING

A. The devices described in this section shall be adjusted accordingly per Manufacturer's recommendations.
B. Clean exposed surfaces using Manufacturer recommended materials and methods.
C. Vacuum all interior spaces.

3.3 TESTING

A. Perform factory and installation tests in accordance with applicable NEC®, NEMA and UL requirements.

3.4 STARTUP SERVICES

A. Engage a factory-authorized service representative to perform startup service.
B. Train City's maintenance personnel on procedures and schedules for energizing and de-energizing, troubleshooting, servicing and maintaining equipment and schedules.
C. Verify that all devices are installed and connected according to the Contract Documents.
D. Verify that electrical control wiring installation complies with Manufacturer's submittal by means of point-to-point continuity testing.
E. Verify that wiring installation complies with requirements in Division 16 Sections.
F. Complete installation and startup checks according to Manufacturer's written instructions.

3.5 WARRANTY (PURCHASE ONLY)

A. Equipment Manufacturer warrants that all goods supplied are free of non-conformities in workmanship and materials for one year from date of initial operation, but not more than eighteen months from date of shipment.

3.6 WARRANTY (PROJECT)

A. Equipment Manufacturer warrants that all goods supplied are free of non-conformities in workmanship and materials for one year from date of Substantial Completion.

End of Section

Section 16110

RACEWAYS, BOXES AND FITTINGS

PART 1 - GENERAL

1.1 SCOPE

A. The CONTACTOR shall furnish and install complete raceway systems as shown on the Contract Drawings and as specified herein.

B. Related Work Specified Elsewhere (if included):
   1. Division 1 – General Requirements;
   2. Division 2 – Site Work;
   3. Division 3 – Concrete;
   4. Division 11 – Equipment;
   5. Division 13 – Special Construction;
   6. Division 15 – Mechanical;
   7. Division 16 – Electrical;

C. Applications
   1. Except where otherwise shown on the Contract Drawings, the following describes the conduit requirements for the project:
      a. All exposed power and control raceways shall be in Rigid Aluminum conduit unless otherwise noted below;
      b. Underground power conductors shall be installed in Rigid Non-metallic (PVC) Schedule 80 conduits, when not encased in concrete duct bank;
      c. All exposed 4-20mA Instrumentation signals shall be installed in Rigid Aluminum conduit;
      d. All fiber-optic cable shall be installed in Rigid Non-metallic (PVC) Schedule 80 conduits, when not encased in concrete duct bank;
      e. Underground 4-20mA Instrumentation signals shall be installed in Rigid Non-metallic (PVC) Schedule 80 conduits, when not encased in concrete duct bank;
      f. Conduit sleeves shall be Rigid Non-metallic (PVC) Schedule 80;
      g. VFD motor conductors shall be installed in Rigid Galvanized Steel PVC Coated (GRS) Conduit;
   2. Wherever Rigid Non-metallic (PVC) Schedule 80 is used, all below grade elbows and risers to above grade shall be Rigid Galvanized Steel PVC Coated Conduit (GRS). All elbows above grade shall be suitably grounded. Conduit spaces shall be provided for underground conduit installation.
   3. All conduit of a given type shall be the product of one Manufacturer.
   4. All switch, outlet and control station boxes and fittings shall be cast aluminum FS boxes with aluminum covers;
   5. Concealed switch, outlet and control station boxes in NEMA 1 areas shall be aluminum;
   6. All terminal boxes, junction boxes, pull boxes installed outdoors shall be NEMA 4X 316 stainless steel.

7. All boxes installed indoors (except in corrosive areas) may be aluminum.
8. Boxes in corrosive areas shall be PVC; Boxes in lift stations shall be fiberglass.
9. Combination expansion-deflection fittings shall be used where exposed or embedded conduits cross structure expansion joints;
10. Maximum conduit pull box spacing shall not exceed 200', two 90° conduit bends and/or maximum pull tension of material(s) not exceeded;

1.2 REFERENCES

A. All characteristics, definitions, and terminology, except as specifically covered in this Specification, shall be in accordance with the latest revision of the following standards:
   1. American National Standards Institute (ANSI)/ Underwriters Laboratories (UL) 651 - Schedule 40 and 80 Rigid PVC Conduit and Fittings;
   2. ANSI/UL 651A - Type EB and A Rigid PVC Conduit and HDPE Conduit;
   3. ANSI C80.1 - Electrical Rigid Steel Conduit (ERSC);
   4. ANSI C80.5 –Electrical Rigid Aluminum Conduit (ERAC)
   5. ANSI/ American Society of Mechanical Engineers (ASME) B1.20.1 - Pipe Threads, General Purpose (Inch);
   6. National Electrical Contractors Association (NECA) National Electrical Installation Standards (NEIS);
   7. NECA 1 - Standard Practice of Good Workmanship in Electrical Construction;
   8. NECA 101 – Standard for Installing Steel Conduit (Rigid, IMC, EMT);
   9. NECA 102 - Standard for Installing Aluminum Rigid Metal Conduit;
   10. NECA 111 - Standard for Installing Nonmetallic Raceways (RNC, ENT, LFNC);
   11. National Electrical Manufacturers Association (NEMA) TC-2 - Electrical Polyvinyl Chloride (PVC) Conduit;
   12. National Fire Protection Association® (NFPA®) 70 – National Electric Code® (NEC®);
   13. NEC® Article 344 – Rigid Metal Conduit: Type RMC;
   14. NEC® Article 350 – Liquidtight Flexible Metal Conduit: Type LFMC;
   15. NEC® Article 352 – Rigid Polyvinyl Chloride Conduit: Type PVC;
   16. NEMA TC-6 & 8 - Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installations;
   17. NFPA® 70E® - Electrical Safety in the Workplace;
   18. Underwriters Laboratories (UL) 5A - Surface Nonmetallic Raceways;
   19. UL 6 - Electrical Rigid Metal Conduit – Steel;
   20. UL 6A - Electrical Rigid Metal Conduit - Aluminum, Red Brass, and Stainless Steel;
   21. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations;

22. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations;
23. UL 94 - Tests for Flammability of Plastic Materials for Parts in Devices and Appliances;
24. UL 360 - Liquid-Tight Flexible Steel Conduit;
25. UL 514A - Metallic Outlet Boxes;
26. UL 514B - Conduit, Tubing, and Cable Fittings;
27. UL 514C - Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers;

1.3 SUBMITTALS

A. Submit shop drawings in accordance with the General Conditions and Section 01420.
B. All submittal documents shall be provided in both hardcopy, bounded in separate three-ring binders, indexed, tabbed with sectional dividers, and no larger than 8½-inch x 11-inch and bookmarked electronic media - Adobe® Acrobat® portable document format. Two sets of hardcopies and two sets of electronic media shall be provided.
C. All drawings shall be provided in both hardcopy, bounded, indexed, and no larger than 11-inch x 17-inch and bookmarked electronic media - Autodesk® AutoCAD® file format AND Adobe® Acrobat® portable document format. Two sets of hardcopies and two sets of electronic media shall be provided.
D. The following information, at a minimum, shall be submitted to the City:
    1. Descriptive bulletins;
    2. Product data sheets;
    3. Master drawing index;
    4. Dimensioned front & plan view of the assembly;
    5. Schematic diagram;
    6. Cable terminal sizes;
    7. Component list;
    8. Wiring diagrams;
    9. Installation information;
E. Submit product data for the following:
    1. Surface raceway and fittings;
    2. Wireway and fittings;
    3. Conduit and fittings for each type specified;
    4. Boxes and cabinets;

1.4 QUALITY ASSURANCE

A. The Manufacturer shall have a minimum of ten (10) years consecutive experience producing similar electrical equipment.
B. The Manufacturer shall be ISO certified.
C. UL Listing Requirements –
    1. “Manufactured in accordance with” is not equivalent to “UL LISTED” and does not meet the intent of this specification;
    2. The Raceways, Boxes & Fittings shall be posted at www.UL.com under the appropriate Category Code. Products without posting at UL.com shall not be approved. To access UL Category Code, click on

Certifications of UL's home page. Type the appropriate code into the Category Code search box and click Search.

D. Contractor shall comply with all NEMA standards pertaining to raceways.
E. Contractor shall comply with requirements of all UL standards pertaining to electrical raceway systems. Provide raceway products and components listed and labeled by UL.

1.5 DELIVERY, STORAGE AND HANDLING

A. Deliver products and equipment in factory labeled packages that include recommended storage practices placed on the outside of the shipping container.
B. Handling and shipment of the products and equipment shall be in such a manner to prevent internal component damage, breakage, and denting and scoring of the enclosure finish.
C. Store and handle in strict compliance with Manufacturer's instructions and recommendations. Protect from potential damage from weather and construction operations. Store so condensation will not form on or in equipment and if necessary, apply temporary heat where required to obtain suitable service conditions.

PART 2 - PRODUCTS

2.1 RIGID STEEL METAL CONDUIT (RSC) AND FITTINGS

A. Material shall meet or exceed the following:
   1. Use under the provisions of NEC® Article 344 - Rigid Metal Conduit: Type RMC;
   2. American National Standards Institute (ANSI) C80.1 - Electrical Rigid Steel Conduit (ERSC);
   3. Rigid steel conduit interior and exterior shall be hot-dipped galvanized;
   4. Minimum ¾-inch conduit shall be specified or used;
B. Fittings
   1. Locknuts: Steel or malleable iron;
   2. Bushings: Threaded type, steel or malleable iron, with 221 °F (105 °C) rated plastic insulated throat. Plastic bushings with a rating of 221 °F (105 °C) may be used for conduits 1-inch and smaller.
   3. Box connectors for damp and wet locations: Provide a watertight threaded hub on enclosure consisting of sealing fitting with tapered conduit thread, neoprene O-ring, and 221 °F (105 °C) rated insulating throat with grounding and bonding lug.
   4. Couplings: Threaded, hot dipped galvanized after fabrication.
C. Long Radius Elbows (90 degrees)
D.

Conduit Size (inches)	Minimum Radius (inches)
¾	12
1	12
1-½	12
2	15
2- ½	15
3	18

3-½	18
4	30
5	36
6	42

E. Acceptable RSC and Fittings Manufacturers
1. ATKORE INTERNATIONAL
www.atkore.com
ALLIED TUBE & CONDUIT
Steel Rigid Conduit;
2. REPUBLIC CONDUIT™
www.republic-conduit.com
Galvite® Electrical Rigid Metal Conduit-Steel;
3. WESTERN TUBE & CONDUIT CORPORATION
www.westerntube.com
Rigid Steel Conduit;
4. WHEATLAND TUBE COMPANY
www.wheatland.com
Rigid Steel Conduit;

2.2 PVC COATED GALVANIZED RIGID STEEL CONDUIT (GRS) AND FITTINGS

A. Material shall meet or exceed the following:
1. Urethane coating on threads;
2. Minimum 40 mil PVC permanently bonded coating on exterior;
3. Minimum 2 mil urethane coating on interior;

B. Acceptable PVC GRS and Fittings Manufacturers
1. CALCONDUIT™
www.calconduit.com
UL Listed PVC Coated Conduit;
2. PERMA-COTE COATED CONDUIT
www.permacote.com
Perma-Cote Coated Conduit & Fittings;
Plasti-Bond Coated Galvanized Rigid Conduit & Fittings;
KorKap® PVC Rigid Metal Conduit & Fittings;
3. THOMAS & BETTS
www.tnb.com
Ocal® PVC Coated Conduit & Fittings;

2.3 RIGID ALUMINUM METAL CONDUIT (RAC) AND FITTINGS

A. Material shall meet or exceed the following:
1. Use under the provisions of NEC® Article 344 - Rigid Metal Conduit: Type RMC;
2. American National Standards Institute (ANSI) C80.5 – Electrical Rigid Aluminum Conduit (ERAC)
3. Underwriters Laboratories (UL) 6A - Electrical Rigid Metal Conduit - Aluminum, Red Brass and Stainless Steel;
4. Minimum ¾-inch conduit shall be specified and used;

B. Acceptable RAC and Fittings Manufacturers

1. ATKORE INTERNATIONAL
   www.atkore.com
   ALLIED TUBE & CONDUIT
   Aluminum Rigid Conduit;
2. REPUBLIC CONDUIT™
   www.republic-conduit.com
   Aluminum Rigid Conduit;
3. WHEATLAND TUBE COMPANY
   www.wheatland.com
   Aluminum Rigid Conduit;

2.4 RIGID ALUMINUM BUSHING

A. Material

B. Acceptable Rigid Aluminum Bushing Manufacturers

1. EGS ELECTRICAL GROUP
   www.o-zgedney.com
   O-Z/GEDNEY
   Type AB - Insulated
   Type ABLG - Grounding
2. City Preapproved Equal

2.5 RIGID ALUMINUM CABLE SEALING FITTING

A. Material

B. Acceptable Rigid Aluminum Cable Sealing Fitting Manufacturers

1. EGS ELECTRICAL GROUP
   www.appletonelec.com
   APPLETON®
   Type CG-S
2. City Preapproved Equal

2.6 RIGID ALUMINUM CONDUIT SEALING FITTING

A. Material

B. Acceptable Rigid Aluminum Conduit Sealing Fitting Manufacturers

1. COOPER INDUSTRIES
   www.crouse-hinds.com
   CROUSE-HINDS®
   Type EYSR
2. City Preapproved Equal

2.7 RIGID ALUMINUM DRAIN SEAL

A. Material

B. Acceptable Rigid Aluminum Drain Seal Manufacturers

1. COOPER INDUSTRIES
   www.crouse-hinds.com
   CROUSE-HINDS®
   Type EYD-SA or Type EZD-SA
2. EGS ELECTRICAL GROUP
   www.appletonelec.com

APPLETON®
Type EYDM-A

3. City Preapproved Equal

2.8 RIGID ALUMINUM DRAIN/BREATHER FITTING

A. Material

B. Acceptable Rigid Aluminum Drain/Breather Fitting Manufacturers

1. COOPER INDUSTRIES
www.crouse-hinds.com
CROUSE-HINDS®
Type ECD
2. EGS ELECTRICAL GROUP
www.appletonelec.com
APPLETON®
Type DB
3. City Preapproved Equal

2.9 RIGID NON-METALLIC CONDUIT (PVC) AND FITTINGS

A. Material shall meet or exceed the following:

1. Use under the provisions of NEC® Article 352 – Rigid Polyvinyl Chloride Conduit: Type PVC;
2. American National Standards Institute (ANSI)/ Underwriters Laboratories (UL) 651 - Schedule 40 and 80 Rigid PVC Conduit and Fittings;
3. NEMA TC-2 - Electrical Polyvinyl Chloride (PVC) Conduit;
4. Minimum 1-inch conduit shall be specified and used;

B. Acceptable PVC and Fittings Manufacturers

1. ATKORE INTERNATIONAL
www.atkore.com
ALLIED TUBE & CONDUIT
UL Listed Rigid Schedule-40 & Schedule-80 PVC Electrical Conduit
2. CANTEX®
www.cantexinc.com
UL Listed Schedule-40 or 80 PVC Electrical Conduit;
3. THOMAS & BETTS
www.carlon.com
CARLON®
Carlon Plus 40® and Plus 80® Rigid PVC Conduit;
4. City Preapproved Equal

2.10 RIGID NON-METALLIC CONDUIT (PVC) TYPE DIRECT BURIAL (DB) CONDUIT AND FITTINGS

A. Material shall meet or exceed the following:

1. Use under the provisions of NEC® Article 352 – Rigid Polyvinyl Chloride Conduit: Type PVC;
2. American National Standards Institute (ANSI)/ Underwriters Laboratories (UL) 651 - Schedule 40 and 80 Rigid PVC Conduit and Fittings;

3. NEMA TC-6 & 8 - Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installations;

B. Acceptable DB PVC and Fittings Manufacturers
1. CANTEX®
www.cantexinc.com
Utility Duct DB60 and DB120;
2. THOMAS & BETTS
www.carlon.com
CARLON®
P&C® Duct DB60 and DB120;
3. City Preapproved Equal

2.11 RIGID NON-METALLIC (PVC) CONDUIT TYPE ENCASED BURIAL (EB) CONDUIT AND FITTINGS

A. Material shall meet or exceed the following:
1. Use under the provisions of NEC® Article 352 – Rigid Polyvinyl Chloride Conduit: Type PVC;
2. American National Standards Institute (ANSI)/ Underwriters Laboratories (UL) 651 - Schedule 40 and 80 Rigid PVC Conduit and Fittings;
3. ANSI/UL 651A - Type EB and A Rigid PVC Conduit and HDPE Conduit;
4. NEMA TC-6 & 8 - Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installations;

B. Acceptable EB PVC and Fittings Manufacturers
1. CANTEX®
www.cantexinc.com
Utility Duct EB20 and EB35;
2. THOMAS & BETTS
www.carlon.com
CARLON®
P&C® Duct EB20 and EB35;
3. City Preapproved Equal

2.12 LIQUIDTIGHT FLEXIBLE METAL CONDUIT (LFMC)

A. Material
1. Use under the provisions of NEC® Article 350 – Liquidtight Flexible Metal Conduit: Type LFMC;
2. Underwriters Laboratories (UL) 360 - Liquid-Tight Flexible Steel Conduit;
3. Hot Dipped Zinc Galvanized Steel Core with Bonding Wire;
4. Polyvinyl Chloride (PVC) Cover;
5. Gray Color;
6. -4 °F to +140 °F (-20 °C to +60 °C) Temperature Range;

B. Acceptable LFMC Manufacturers
1. AFC CABLE SYSTEMS®, INC.
www.afcweb.com
LIQUID-TUFF™

UL Liquidtight Flexible Steel Conduit, Type LFMC;
2. ANAMET ELECTRICAL, INC.
www.anacondasealtite.com
Anaconda Sealtite®
Flexible Conduit, Product Type UA – UL Listed;
3. City Preapproved Equal

2.13 LIQUIDTIGHT FLEXIBLE METAL (LFMC) FITTINGS

A. Material shall meet or exceed the following:
1. Use under the provisions of NEC® Article 350 – Liquidtight Flexible Metal Conduit: Type LFMC;
2. Underwriters Laboratories (UL) 514B - Fittings for Cable and Conduit;
3. ANSI/NEMA FB-1;
4. Heavy-duty, impact resistant construction;
5. Factory installed “O” ring seals against lubricants and other liquids;
6. All malleable iron construction;
7. Full-size UL locknut;
8. Threaded locking mechanism;
9. Outer bushing conforms to nut and conduit;

B. Acceptable LFMC Fittings Manufacturers
1. AFC CABLE SYSTEMS®, INC.
www.afcweb.com
Malleable Iron Liquidtight Insulated Fittings;
2. THOMAS & BETTS
www.tnb.com
Malleable Iron Liquidtight Insulated Fittings;
3. City Preapproved Equal

2.14 CONDUIT BODIES

A. Applications - Serve as pulling fittings; Make bends in conduit system; Provide openings for splicing; Connect and change direction of conduit runs; Allow connections for branch runs; Permit access to conductors for maintenance. Among the types are:
1. L-shaped bodies ("Ells") include the LB, LL, and LR, where the inlet is in line with the access cover and the outlet is on the back, left and right, respectively. In addition to providing access to wires for pulling, "L" fittings allow a 90° turn in conduit where there is insufficient space for a full-radius 90° sweep (curved conduit section).
2. T-shaped bodies ("Tees") feature an inlet in line with the access cover and outlets to both the cover's left and right.
3. C-shaped bodies ("Cees") have identical openings above and below the access cover and are used to pull conductors in straight runs as they make no turn between inlet and outlet.
4. Service "Ells" (SLBs), shorter with inlets flush with the access cover, are frequently used where a circuit passes through an exterior wall from outside to inside.
5. Mogul bodies are used for large and heavy conductor pulls;

B. Rigid Steel, Rigid Aluminum Conduit Bodies (Non-hazardous)
   1. National Electrical Manufacturers Association (NEMA) FB-1 - Fittings, Cast Metal Boxes, And Conduit Bodies for Conduit, Electrical Metallic Tubing, And Cable;
   2. Underwriters Laboratories (UL) 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations;
   3. UL 514A - Metallic Outlet Boxes;
   4. UL 514B - Conduit, Tubing, and Cable Fittings;

C. Acceptable Rigid Steel, Rigid Aluminum Conduit Bodies (Non-hazardous) Manufacturers
   1. COOPER INDUSTRIES
      www.crouse-hinds.com
      CROUSE-HINDS®
      Condulet® Form 7™ Conduit Bodies;
      Use Cast Iron Bodies & Sheet Steel Wedge nut w/Integral Gasket for Rigid Steel Installations;
      Use Aluminum Bodies & Sheet Aluminum Wedge nut w/Integral Gasket for Rigid Aluminum Installations;
   2. EGS ELECTRICAL GROUP
      www.appletonelec.com
      APPLETON®
      FM7™ Unilet® Conduit Outlet Bodies;
      Use Grayloy-iron Bodies & Steel Wedge-Lok™ Stamped Covers for Rigid Steel Installations;
      Use Copper free aluminum Bodies and Aluminum Wedge-Lok™ Stamped Covers for Rigid Aluminum Installations;
   3. HUBBELL® INC.
      www.hubbell.com
      www.hubbell-killark.com
      KILLARK® Series O,
      Type E Electrolets
   4. City Preapproved Equal

D. Rigid Non-Metallic (PVC) Conduit Bodies (Non-hazardous)
   1. NEMA OS-2 - Nonmetallic Outlet Boxes, Device Boxes, Covers and Box Supports;
   2. UL 514C - Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers;

E. Acceptable Rigid Non-Metallic (PVC) Conduit Bodies (Non-hazardous) Manufacturers
   1. CANTEX®
      www.cantexinc.com
      (PVC) Conduit Bodies;
   2. THOMAS & BETTS
      www.carlon.com
      CARLON®
      Rigid Nonmetallic Conduit Bodies;
   3. City Preapproved Equal

F. Rigid Steel, Rigid Aluminum Conduit Bodies (Hazardous)

G. Acceptable Rigid Steel, Rigid Aluminum Conduit Bodies (Hazardous) Manufacturers
   1. COOPER INDUSTRIES
      www.crouse-hinds.com
      CROUSE-HINDS®
      Condulet® OE Series Explosion-proof Conduit Outlet Bodies
   2. EGS ELECTRICAL GROUP
      www.appletonelec.com
      APPLETON®
      ER Conduit Outlet Boxes
   3. City Preapproved Equal
H. Specialty Conduit and Fittings (Hazardous)
I. Acceptable Specialty Conduit and Fittings (Hazardous) Manufacturers
   1. COOPER INDUSTRIES
      www.crouse-hinds.com
      CROUSE-HINDS®
      EYSR Explosion-Proof Seal-offs;
   2. City Preapproved Equal

2.15 OUTLET BOXES
A. Applications:
   1. Accommodate wiring devices;
   2. Act as pull boxes for conductors in a conduit system;
   3. Provide openings to make splices and taps in conductors;
   4. Provide access to conductors for maintenance and future system changes;
   5. Connect conduit sections;
B. Cast Metal (Non-hazardous)
   1. Box: Cast ferrous metal;
   2. Cover: Gasketed, weatherproof, cast ferrous metal with stainless steel screws;
   3. Hubs: Threaded;
   4. Lugs: Cast Mounting;
C. Acceptable Cast Metal (Non-hazardous) Manufacturers
   1. COOPER INDUSTRIES
      www.crouse-hinds.com
      CROUSE-HINDS®
      Type FS (Shallow) or FD (Deep);
   2. EGS ELECTRICAL GROUP
      www.appletonelec.com
      APPLETON® or
      O-Z/GEDNEY
      Type FS (Shallow) or FD (Deep);
   3. City Preapproved Equal
D. Cast Aluminum (Non-hazardous)
   1. Box: cast copper-free aluminum;
   2. Cover: Gasketed, weatherproof, cast copper-free aluminum with stainless steel screws;

3. Hubs: Threaded;
4. Lugs: Cast Mounting;

E. Acceptable Cast Aluminum (Non-hazardous) Manufacturers
1. COOPER INDUSTRIES
www.crouse-hinds.com
CROUSE-HINDS®
Type FS-SA or FD-SA;
2. EGS ELECTRICAL GROUP
www.appletonelec.com
APPLETON® or
O-Z/GEDNEY
Type FS or FD;
3. City Preapproved Equal

F. Aluminum (Hazardous)

G. Acceptable Aluminum (Hazardous) Manufacturers
1. COOPER INDUSTRIES
www.crouse-hinds.com
CROUSE-HINDS®
Condulet® Series Explosion-proof Outlet Boxes
2. EGS ELECTRICAL GROUP
www.appletonelec.com
APPLETON®
OE Conduit Outlet Boxes
3. City Preapproved Equal

H. Metal/Aluminum DIN Mountable (Non-hazardous)
1. DIN mount Surge Protected Dual Outlet for 120VAC, 15A Service;

I. Acceptable Metal/Aluminum DIN Mountable (Non-hazardous) Manufacturers
1. HUBBELL® INC.
www.hubbell-wiring.com
DIN Rail Utility Box,
Part No. DRUBTVSS15;
2. PHOENIX CONTACT
www.phoenixcon.com
EM-DUO-120/15/SPD
Part No. 56 01 28 3;
3. City Preapproved Equal

J. Non-Metallic
1. Box: PVC;
2. Cover: PVC, weatherproof, with stainless steel screws;

K. Acceptable Non-Metallic Manufacturers
1. CANTEX®
www.cantexinc.com
Type FS or FS
With Weatherproof covers;
2. THOMAS & BETTS
CARLON®

www.carlon.com
Type FS or FD
with Type E98 or E96 covers;

3. City Preapproved Equal

2.16 BOXES, JUNCTION AND PULL

A. Aboveground Material
1. Stainless Steel – NEMA 4X:
2. Type 316 stainless steel (Continuous-hinge with clamps (bolted or screwed) covers with gaskets;
3. If used for a terminal junction box, provide terminal strips or terminal blocks with a separate connection point for each conductor entering or leaving the box. Also, provide a minimum of 25% spare terminal points);
4. ALL NEMA 4X Large (≥24-inch Height x 20-inch Wide) Wall-Mount shall have continuous-hinge with 3-Point Latch;

B. Acceptable Aboveground Boxes, Junction and Pull Manufacturers
1. PENTAIR TECHNICAL PRODUCTS HOFFMAN®
www.hoffmanonline.com
HOFFMAN® Stainless Steel Continuous Hinge Type 4X CHNFSS Junction Boxes
Continuous Hinge with 3-Point Latch, Type 4X SSLP3PT Enclosures
2. RITTAL CORP.
www.rittal.com
NEMA 4X Junction Boxes;
3. City Preapproved Equal

C. Underground Material (i.e. Pull Box, Junction Box, Hand Hole, Splice Box)
1. Fiberglass/Polymer Concrete;
2. Lightweight;
3. Designed for Tier 8 (12,000lbs) applications;
4. Flared design;
5. Minimum 18” Depth;
6. Bolted Cover;
7. Cover Marking – as required (i.e. ELECTRIC, CONTROL, FIBER);

D. Acceptable Underground Boxes, Junction and Pull Manufacturers
1. HIGHLINE PRODUCTS
www.highlineproducts.com
Composite Hand hole Assembly
CHA Series;
2. HUBBELL® POWER SYSTEMS
www.hubbellpowersystems.com
QUAZITE® Below Ground Flared CDR Style;
3. City Preapproved Equal

2.17 RIGID METAL CONDUIT FITTINGS

A. Acceptable Rigid Metal Conduit Fittings Manufacturers
1. ARLINGTON INDUSTRIES
www.aifittings.com

Locknuts, Plastic Insulating Bushings
2. THOMAS & BETTS
www.tnb.com
Locknuts, Sealing Locknuts, Bonding Locknuts, Threaded Insulated Grounding Bushings
3. City Preapproved Equal

2.18 RIGID ALUMINUM EXPANSION FITTING
A. Acceptable Rigid Aluminum Expansion Fitting Manufacturers
1. COOPER INDUSTRIES
www.crouse-hinds.com
CROUSE-HINDS®
XD Series Expansion/Deflection Couplings;
2. THOMAS & BETTS
www.tnb.com
T&B® XD Series
Expansion/Deflection Couplings;
3. City Preapproved Equal

2.19 CONDUIT SEALS
A. For Sealing Around Conduit Passing through a Wall or Floor;
B. Acceptable Conduit Seals Manufacturers
1. EGS ELECTRICAL GROUP
www.o-zgedney.com
O-Z/GEDNEY
Type WSK;
2. City Preapproved Equal

2.20 CONDUIT SEALING BUSHINGS
A. For Use with Insulated Wire, Cable and Rigid Metal Conduit; Sealing Bushings are used to seal against fluid and gas pressure around mechanical pipes, casing, conduits or tubes.
B. Acceptable Conduit Sealing Bushings Manufacturers
1. EGS ELECTRICAL GROUP
www.o-zgedney.com
O-Z/GEDNEY
Type CSB or CSM Series;
2. EGS ELECTRICAL GROUP
www.o-zgedney.com
O-Z/GEDNEY
Type CSM Series CSML;
3. EGS ELECTRICAL GROUP
www.o-zgedney.com
O-Z/GEDNEY
Type CSM Series CSMI;
4. City Preapproved Equal

2.21 CONDUIT MOUNTING HARDWARE

A. Reference Section 16190 - Supporting Devices.
   1. REFERENCE
      SECTION 16190
      SUPPORTING DEVICES
   2. NO EQUAL

2.22 CONDUIT & FITTINGS CORROSION PROTECTIVE COATINGS

A. Acceptable Conduit & Fittings Corrosion Protective Coatings Manufacturers
   1. THOMAS & BETTS
      www.tnb.com
      Kopr-Shield® Compound
   2. CARBOLINE® COMPANY
      www.carboline.com
      Carbomastic®
   3. PORTER PAINT CO.
      www.porterpaints.com
      PorterTuf™ 2000 HB Coal Tar Epoxy
   4. City Preapproved Equal

2.23 GALVANIZING REPAIR STICK

A. A galvanizing repair stick shall be heated and applied like a crayon to repair nicks and scratches on conduit; It offers superior protection of ferrous metals and bond to both iron or steel;
B. Acceptable Galvanizing Repair Stick Manufacturers
   1. ROTOMETALS, INC.
      www.rotometals.com
      “REGALV” Galvanizing Repair Stick-Lead Free;
   2. City Preapproved Equal

2.24 ANTI-SEIZE/ANTI-CORROSION (COPPER) COMPOUND

A. Copper anti-seize, anti-corrosion compound shall be applied to the threads of all bolts & screws prior to installation.
B. The anti-seize, anti-corrosion compound shall be appropriate to the hardware material being assembled.
C. Use on all types of threaded connections, bushings, keyways, press fits, etc. to protect against seizure, heat freeze, galling, rust and corrosion.
D. Acceptable Anti-Seize/Anti-Corrosion (Copper) Compound Manufacturers
   1. CRC® INDUSTRIES, INC.
      www.crcindustries.com
      Sta-Lube Copper Anti-Seize;
   2. HENKEL CORPORATION
      www.loctite.com
      LOCTITE® C5-A®;
   3. JET LUBE®
      www.jetlube.com
      KOPR-KOTE®;
   4. PERMATEX®, A Division of ITW

www.permatex.com
Copper Anti-Seize;

PART 3 - EXECUTION

3.1 INSTALLATION

A. Conduit Usage Schedule: Install the following types of conduits and fittings in locations listed, unless otherwise noted in the Contract Drawings. Definitions and requirements of NEC® apply unless specifically modified below.
   1. Exterior and interior, exposed:
      a. Material: Rigid Aluminum Conduit except PVC Schedule 80 for armored cables;
      b. Minimum size: 1 -inch;
   2. Everywhere else:
      a. Material: PVC Schedule 80;
      b. Minimum size: 1-inch;
   3. Embedded in Concrete:
      a. Material: Rigid Aluminum Conduit or PVC Type EB;
      b. Minimum size: 1-inch;
   4. In earth below concrete slabs:
      a. Material: PVC Schedule 40. Rigid steel ells for bends exceeding 45°;
      b. Minimum size: 1-inch;
   5. Conduit stub-ups: Rigid Galvanized Steel PVC Coated Conduit (GRS) long radius ells for stub-ups that connect to underground rigid PVC conduit.
   6. Final Connections to transformers, vibrating equipment or instruments:
      a. Material: Schedule 80 flexible PVC.
      b. Minimum size: 1-inch;

B. General Conduit Installation
   1. No conduit smaller than 1-inch electrical trade size shall be used;
   2. No more than three (3) 90° bends in any one run shall be used;
   3. Conduit runs are shown schematically on the Contract Drawings;
   4. Pull boxes, junction boxes, and other ancillary equipment are not usually shown on the Contract Drawings. The Contractor shall provide as specified in this specification and required by NEC®;
   5. Conduits, fittings and junction boxes for lighting, receptacles and outlets are not shown for clarity. Provide as required by NEC®. Provide additional pull boxes and junction boxes to permit pulling of wires without damage to the conductors or insulation.
   6. Minimum size in floor slabs shall be 1-inch;
   7. No conductor shall be pulled until the conduit system is complete in all details; in the case of concealed work, until all rough plastering or masonry has been completed; in the case of exposed work, until the conduit system has been completed in every detail;
   8. Reference Section 16110-2.23. Anti-Seize/Anti-Corrosion (Copper) Compound;

9. Cap all conduits with Manufacturer-approved caps immediately after installation to prevent entrance of foreign matter.
10. Conduit supports shall be spaced at intervals as required to obtain rigid construction, but in no case less than as required by the NEC®;
11. Single conduits shall be supported by means of one-hole pipe clamps in combination with one-screw back plates to raise conduits from the surface. Reference 16110-2.21. Conduit Mounting Hardware;
12. Multiple runs of conduits shall be supported on trapeze type hangers with horizontal members and threaded hanger rods. The rods shall not be less than 3/8-inch diameter. Reference 16110-2.21. Conduit Mounting Hardware;
13. Conduit hangers shall be attached to structural steel by means of beam or channel clamps; Where attached to concrete surfaces, concrete inserts of the spot type shall be provided;
14. All conduits of exposed work shall be run at right angles to and parallel and perpendicular to surface or exposed structural members and follow surface contours as much as practical to provide a neat appearance; No diagonal runs will be allowed; Bends in parallel conduit runs shall be concentric; all conduits shall be run perfectly straight and true; Conduits not installed in this fashion shall be replaced entirely at the Contractor's expense with no cost to the City.
15. Make right angle bends in conduit runs with long radius elbows or conduits bent to radii not less than those of specified for long radius ells.
16. No unbroken conduit runs shall exceed 200-feet in length. This length shall be reduced by 75-feet for each 90° elbow;
17. The location of all junction boxes must be approved by the Engineer and City before installation;
18. Conduit Terminations:
    a. Terminate all conduits with locknuts and grounding bushings; Conduit terminating in pressed steel boxes shall have double locknuts and insulated bushings installed; Conduit terminating in gasketed enclosures shall be terminated with conduit hubs;
    b. Install conduits squarely to the box and provide one locknut outside the box and one locknut and grounding bushing inside the box.
    c. Install locknuts with dished side against the box.
    d. When terminating in threaded hubs, screw the conduit or fitting tight into the hub so that the end bears against the wire protection shoulder.
    e. When chase nipples are used, install the raceway and coupling square to the box and tighten the chase nipple leaving no exposed threads.
    f. Metallic conduit entering manholes and below grade pull boxes shall be terminated with grounding type bushings and connected together to a ¾ -inch x 20-foot ground rod with a minimum #6 bare copper wire or larger per NEC®;

19. Conduit wall seals shall be used for all conduits penetrating walls below grade or other locations shown on the Contract Drawings;
20. Provide expansion fittings for raceways crossing expansion joints in structures and in straight runs exceeding 100-feet and as shown in NEC®;
21. The distance between pull boxes shall not exceed 200 feet;
22. Explosion-proof flexible couplings shall be used in all hazardous locations;
23. Conduit stub outs for future construction shall be provided with threaded PVC end caps at each end;
24. Underground 120VAC circuits (Schedule 80 PVC) shall be installed directly to the respective lighting panel;
25. Stainless steel pull boxes shall be wall-mounted on structures to eliminate excessive bends;
26. A formed, 3-½-inch high, with 3-inch minimum on each side, concrete conduit housekeeping pad shall be required for all exposed conduit stub-ups; This applies to ALL exposed conduits installed indoors or outdoors;
27. Always install and leave a nylon pull string in all conduits for future pulls;

C. Rigid Nonmetallic (PVC) Conduit Requirements
1. Comply with the installation provisions of NEMA Standard TC2, except as modified below.
2. Make cuts with a fine tooth handsaw. For sizes two-inches and larger, use a miter box or similar saw guide to assure a square cut.
3. Use factory made couplings for joining conduit.
4. Any PVC Conduit bends greater than 22 ½-degrees, install factory-manufactured PVC Coated Galvanized Rigid Steel Conduit (GRS) elbows with approved changeover coupling.
5. Cementing and joining operation shall not exceed 20-seconds. Do not disturb joint for five-minutes, longer (up to 10-minutes) at lower temperatures. Make joints watertight. Joining procedure shall conform to the detailed procedures of ASTM D-2855.
6. Install expansion fittings. Expansion fittings are required when the conduit is left exposed in trenches for a period of time during which the conduit's temperature can vary more than 36 °F (2 °C). Install expansion fittings near the fixed end of the run and 100-feet on center.
7. Install runs of multiple conduits with spacers, of type recommended by the Manufacturer, placed 3 feet on centers.
8. Provide expansion joints as shown in Article 352 of NEC®.

D. Liquidtight Flexible Metal Conduit Requirements
1. All Liquidtight flexible metal conduits with separate dedicated grounding conductor shall be used for all motor terminations and other equipment where vibration is present;

E. Conduit Sealing
1. Seal conduit entries with silicone sealant as follows:

a. When located out-doors, in damp or wet locations, in areas with corrosive atmosphere, or when the enclosure is indicated as weatherproof.
b. At entrance to equipment enclosures.

2. The City shall witness the installation of all sealant;

F. Grounding
1. Install a separate equipment-grounding conductor in all conduits (power, telephone, communication, Fire Alarm, Public Address, paging, sound, CATV, instrumentation and control.)
2. Use grounding bushings for all conduits;
3. Provide a grounding conductor in flexible conduit, size conforming to NEC® Article 250 - Equipment Grounding Conductors.

G. Damaged Conduit
1. Repair or replace conduit damaged during or after installation.
2. Replace crushed or clogged conduit or any conduit whose inner surface is damaged or not smooth.
3. Repair cuts, nicks, or abrasions in the zinc coating of galvanized conduit with galvanizing repair stick;

H. Empty Conduit
1. Provide 200-pound strength nylon pull cord in all empty conduits.
2. Provide a waterproof label on each end of the pull cords to indicate the destination of the other end.

I. Pull Boxes
1. Support wall-mounted pull boxes and panels with Type 316 stainless steel preformed channels and Type 316 stainless steel concrete anchors.

3.2 ADJUSTING AND CLEANING

A. Upon completion of the installation of raceways and boxes, the Contractor shall inspect interiors of raceways and boxes and adjust accordingly per Manufacturer's recommendations.
B. Clean exposed surfaces using Manufacturer recommended materials and methods.
C. Clean with wire brush 1 size larger than conduit and mandrel with 1 size smaller than mandrel.
D. Vacuum all interior spaces.

3.3 TESTING

A. Perform factory and installation tests in accordance with applicable NEC®, NEMA and UL requirements.

3.4 STARTUP SERVICES

A. Verify that all devices are installed and connected according to the Contract Documents.
B. Verify that raceway installation complies with requirements in Division 16 Sections.

3.5 WARRANTY

A. Equipment Manufacturer warrants that all goods supplied are free of non-conformities in workmanship and materials for one year from date of Substantial Completion.

End of Section

Section 16120

WIRES AND CABLES – 600-VOLT AND LESS

PART 1 - GENERAL

1.1 SCOPE

A. This section describes materials, installation and testing of wires and cables operating at 600VAC and lower, which are used for distribution of power, non-power-limited control circuits and industrial communications.

B. Related Work Specified Elsewhere (if included):
   1. Division 1 – General Requirements;
   2. Division 2 – Site Work;
   3. Division 3 – Concrete;
   4. Division 11 – Equipment;
   5. Division 13 – Special Construction;
   6. Division 15 – Mechanical;
   7. Division 16 – Electrical;

C. Furnish, install and test all wire, cable and appurtenances as shown on the Contract Drawings, in accordance with the Manufacturer's recommendations and as hereinafter specified.

1.2 REFERENCES

A. All characteristics, definitions, and terminology, except as specifically covered in this Specification, shall be in accordance with the latest revision of the following standards:
   1. American Society for Testing and Materials (ASTM) B-8 - Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft;
   2. ASTM B-33 - Tinned Soft or Annealed Copper Wire;
   3. American National Standards Institute (ANSI)/ National Electrical Manufacturers Association (NEMA) WC 70-2009/Insulated Cable Engineers Association (ICEA) S-95-658-2009 Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy;
   4. ANSI/Underwriters Laboratories (UL) 44 - Thermoset-Insulated Wires and Cables;
   5. ANSI/UL 62 - Flexible Cords and Cables;
   6. ANSI/UL 66 - Fixture Wire;
   7. ANSI/UL 83 - Thermoplastic-Insulated Wires and Cables;
   8. ANSI/UL 493 - Thermoplastic-Insulated Underground Feeder and Branch-Circuit Cables;
   9. ANSI/UL 854 - Service-Entrance Cables;
   10. ANSI/UL 1581 - Safety for Electrical Wires, Cables, and Flexible Cords;
   11. ICEA T-29-520 - Vertical Cable Tray Flame Tests @ 210,000 BTU;
   12. Institute of Electrical and Electronics Engineers (IEEE) 323-1974 - Qualifying Class 1E Equipment for Nuclear Power Generating Stations;

13. IEEE 383-1974 – Type Test of Class 1E Electric Cables, Field Splices and Connections for Nuclear Power Generating Stations;
14. National Electrical Contractors Association (NECA) National Electrical Installation Standards (NEIS);
15. NECA 1 - Standard Practice of Good Workmanship in Electrical Construction;
16. National Fire Protection Association® (NFPA®) 70 – National Electrical Code® (NEC®);
17. NFPA® 70E® - Electrical Safety in the Workplace;
18. NFPA® 79 - Electrical Standard for Industrial Machinery;
19. UL 486A-486B – Wire Connectors;
20. UL 1063 - Machine-Tool Wires and Cables;
21. UL 2556 - Wire and Cable Test Methods;
22. UL VW-1 - Vertical-Wire Flame Test;

1.3 SUBMITTALS

A. Submit shop drawings in accordance with the General Conditions and Section 01420.
B. All submittal documents shall be provided in both hardcopy, bounded in separate three-ring binders, indexed, tabbed with sectional dividers, and no larger than 8½-inch x 11-inch and bookmarked electronic media - Adobe® Acrobat® portable document format. Two sets of hardcopies and two sets of electronic media shall be provided.
C. All drawings shall be provided in both hardcopy, bounded, indexed, and no larger than 11-inch x 17-inch and bookmarked electronic media - Autodesk® AutoCAD® file format AND Adobe® Acrobat® portable document format. Two sets of hardcopies and two sets of electronic media shall be provided.
D. Contractor shall submit Manufacturer's sample and data for each conductor and cable type to be used on the project for Engineer’s and City’s approval. Each sample shall have the size, type of insulation and voltage stenciled on the jacket. Indicate insulation and jacket types and thickness, insulation color or surface printing code, UL Listing data and other data pertinent to the specific cable that demonstrates and states compliance with the specifications.
E. Any Contractor installed, unapproved wire and/or cable shall be removed and replaced at no additional cost to the City.
F. When factory tests are specified, provide specific details of the test conditions and a certificate that the product furnished has passed the test.

1.4 QUALITY ASSURANCE

A. The Manufacturer shall have a minimum of ten (10) years consecutive experience producing similar electrical equipment.
B. The Manufacturer shall be ISO certified.
C. UL Listing Requirements –
    1. “Manufactured in accordance with” is not equivalent to “UL LISTED” and does not meet the intent of this specification;

2. The Wires and Cables shall be posted at www.UL.com under the appropriate Category Code. Products without posting at UL.com shall not be approved. To access UL Category Code, click on Certifications of UL's home page. Type the appropriate code into the Category Code search box and click Search.

1.5 APPLICATIONS (FACILITIES ONLY)

A. Wire for lighting and receptacle circuits above grade shall be type "XLPE (cross-linked polyethylene) High Heat-resistant Water-resistant" aka XHHW.

1.6 APPLICATIONS (LIFT STATIONS ONLY)

A. Wire for lighting and receptacle circuits above grade shall be type "Thermoplastic High Heat-resistant Nylon coated" aka THHN.
B. Wire for all underground shall be type XHHW. (LIFT STATIONS ONLY)
C. Wire for all underground shall be type THHN.
D. Wire for all power motor circuits below 5 HP shall be type XHHW. (LIFT STATIONS ONLY)
E. Wire for all power motor circuits below 5 HP shall be type THHN.
F. Single conductor wire for control, indication and metering shall be type "Machine Tool Wire" aka MTW 16 AWG, 19-strand for inside control panel applications and type XHHW 14 AWG, 19-strand for outside of control panel applications. (LIFT STATIONS ONLY)
G. Single conductor wire for control, indication and metering shall be type "Machine Tool Wire" aka MTW 16 AWG, 19-strand for inside control panel applications and type THHN 16 AWG, 19-strand for outside of control panel applications.
H. Multi-conductor instrumentation/control cable:
I. Within a control panel shall be shielded 18 AWG, 19-strand;
J. In the field shall be shielded 16 AWG, 19-strand;
K. DLO shall be used for 5 HP motors and above from motor controller to motor connection enclosure.

1.7 MINIMUM SIZES

A. Except for control, communication and signal leads, no conductor smaller than 16 AWG shall be used.

1.8 WIRE/CABLE TAGGING AND COLOR CODING

A. All control circuits and wiring shall be clearly and permanently numbered and labeled at each end so as to identify the location of the opposite end and the function of the circuit. All numbering/ID tagging of cable/conductor's methods shall be in accordance with the City's Wire Tagging Standard as indicated on the Contract Drawings. Method of wire/cable tagging must be approved in a shop drawing prior to any installation. Individual wires in a multi-wire circuit shall be identified with

wire number labels as specified in this section. Labeling shall be in place prior to turnover of any equipment, system or sub-system to the City.

B. The conductor insulation jacket of 4/0 wire and smaller shall be color coded continuous throughout the length of the wire. The installation of color coded tape on the wire conductor as a permanent marking will not be accepted. Color code system shall be as follows:
   1. Conductor Color Coding 208/120VAC & 480/277VAC
      208/120VAC Wye
      BLACK - Phase A
      RED - Phase B
      BLUE - Phase C
      WHITE - Neutral
      GREEN - Ground
      480VAC Delta and 480/277VAC Wye
      BROWN - Phase A
      ORANGE - Phase B
      YELLOW - Phase C
      GRAY - Neutral
      GREEN - Ground
   2. Conductor Color Coding VDC
      24/48VDC
      BLUE - +24
      GREY - –24
      BLUE/RED STRIPE - +48
      GREY/WHITE STRIPE - –48
      125VDC
      RED - +125V
      BLACK – -125V

C. The conductor insulation jacket of wire larger than 4/0 shall be color coded with tape every 10-foot throughout the length of the wire and at each end. Color code system shall be as above.

D. Wire tag labels shall be a:
   1. Self-laminating thermal transfer label with a white printable area with a permanent acrylic adhesive;
   2. Heat shrinkable and thermal transfer wire identification sleeves;
   3. Refer to Section 16040 - Electrical Identification for specifics;

1.9 DELIVERY, STORAGE AND HANDLING

A. Deliver products and equipment in factory labeled packages.

B. Handling and shipment of the products and equipment shall be in such a manner to prevent internal component damage, breakage, and denting and scoring of the enclosure finish.

C. Store and handle in strict compliance with Manufacturer’s instructions and recommendations. Protect from potential damage from weather and construction operations. Store so condensation will not form on or in equipment and if necessary, apply temporary heat where required to obtain suitable service conditions.

PART 2 - PRODUCTS

2.1 WIRE AND CABLES

A. The listing of specific Manufacturers does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed are not relieved from meeting these specifications in their entirety.

B. All wires and cables shall be annealed, 98% conductivity, soft-drawn stranded copper conductors;

C. Wire for Aboveground Lighting & Receptacle Circuits

D. Acceptable Wire for Aboveground Lighting & Receptacle Circuits Manufacturers

1. GENERAL CABLE® CO.
   www.generalcable.com
   Type XHHW;
2. SOUTHWIRE® CO.
   www.southwire.com
   Type XHHW;
3. City Preapproved Equal

E. Wire for Aboveground Lighting & Receptacle Circuits (LIFT STATIONS ONLY)

F. Acceptable Wire for Aboveground Lighting & Receptacle Circuits Manufacturers (LIFT STATIONS ONLY)

1. GENERAL CABLE® CO.
   www.generalcable.com
   Type THHN;
2. SOUTHWIRE® CO.
   www.southwire.com
   Type THHN;
3. City Preapproved Equal

G. Wire for All Underground and below 5 HP Motor Circuits

H. Acceptable Wire for All Underground and below 5 HP Motor Circuits Manufacturers

1. GENERAL CABLE® CO.
   www.generalcable.com
   Type XHHW;
2. SOUTHWIRE® CO.
   www.southwire.com
   Type XHHW;
3. City Preapproved Equal

I. Wire for All Underground and below 5 HP Motor Circuits (LIFT STATIONS ONLY)

J. Acceptable Wire for All Underground and below 5 HP Motor Circuits Manufacturers (LIFT STATIONS ONLY)

1. GENERAL CABLE® CO.
   www.generalcable.com
   Type THHN;
2. SOUTHWIRE® CO.

www.southwire.com
Type THHN;
3. City Preapproved Equal

K. Wire for All 5 HP and Above Motor Circuits

L. Acceptable Wire for All 5 HP and Above Motor Circuits Manufacturers
1. GENERAL CABLE® CO.
www.generalcable.com
CAROL® Brand
SUPER VU-TRON® EPR/CPE;
2. SOUTHWIRE® CO.
www.southwire.com
2KV Diesel Locomotive Cable;
3. City Preapproved Equal

M. Single-Conductor Wire for Control, Indication and Metering including:
1. DC Power Interior Control Panel Wiring, MTW-AWM-UL1015 16 AWG;
2. Discrete I/O Interior Control Panel Wiring, MTW-AWM-UL1015 16 AWG;
3. Discrete I/O Field Wiring, MTW-AWM-UL1015 14 AWG;

N. Acceptable Single-Conductor Wire for Control, Indication and Metering Manufacturers
1. GENERAL CABLE® CO.
www.generalcable.com
Hook-Up Wire UL Types MTW, TFF, AWM and CSA TEW;
2. SOUTHWIRE® CO.
www.southwire.com
MTW/TEW or AWM-I A;
3. City Preapproved Equal

2.2 INSTRUMENTATION CABLES

A. All wires and cables shall be annealed, 98% conductivity, soft-drawn stranded copper conductors;

B. Multi-Conductor Instrumentation and Control Cable
1. Gray color jacket;
2. Two (2) and Four (4) conductor, 18 AWG stranded tinned-copper conductors for control panel wiring;
3. Four (4) conductor, 16 AWG stranded tinned-copper conductors for field wiring;
4. Foil Shield with drain;
5. Two (2) and Four (4) conductor Polyvinyl Chloride (PVC) insulation and jacket for control panel applications;
6. Four-conductor Fluorinated Ethylene Propylene (FEP) insulation and jacket for field applications;
7. Field cable shall be plenum rated;
8. Conductor Colors: Two-conductor: Black, White (or Clear), or Four-conductor: Black, White, Red, Green;
9. For use on Security Systems, Intercom/PA Systems, Sound/Audio Systems, Power Limited Controls and Instrumentation;
10. Analog Input/output Field Wiring, (Current/Voltage);

11. Analog Input/output Interior Control Panel Wiring (Current/Voltage);
12. Black (-) and White (or Clear) (+) for signal and Green (-) and Red (+) for power;

C. Acceptable Multi-Conductor Instrumentation and Control Cable Manufacturers
1. BELDEN®
www.belden.com
Part No. 8760 Two-Conductor and
Part No. 9418 Four-Conductor PVC for control panel applications;
Part No. 6202FE Four-Conductor, FEP for field applications;
2. GENERAL CABLE® CO.
www.generalcable.com
Part No. C2534A Two-Conductor and
Part No. C2543A Four-Conductor PVC for control panel applications;
Part No. C3341 Four-Conductor FEP for field wiring;
3. City Preapproved Equal

D. Analog Input (3 Wire RTD) Cable
1. Three (3) conductor;
2. 22AWG, stranded tinned-copper conductors, shield;
3. For non-plenum applications, use Polyvinyl Chloride (PVC) insulation and jacket;
4. For plenum applications, use Fluorinated Ethylene Propylene (FEP) insulation and jacket;

E. Acceptable Analog Input (3 Wire RTD) Cable Manufacturers
1. ALPHA WIRE
www.alphawire.com
Part No. 6339 PVC;
2. BELDEN®
www.belden.com
Part No. 9939 PVC;
Part No. 83553 FEP;
3. City Preapproved Equal

2.3 COMMUNICATION CABLES

A. To minimize damage caused by lightning, all outdoor communication s shall use fiber-optics as specified in Section 13300. Transitions from fiber-optics to metallic cables shall be kept to a minimum.

B. Where specified, use the appropriate specified cable for indoor or outdoor application.

C. PROFIBUS® DP™ Cable
1. Purple color jacket;
2. Red/Green;
3. 2 conductor, twisted, stranded, shield;

D. Acceptable PROFIBUS® DP™ Cable Manufacturers
1. BELDEN®
www.belden.com
Part No. 3079E;
2. SIEMENS INDUSTRY

www.automation.siemens.com
PROFIBUS® Flexible,
Part No. 6XV1 830-0PH10;

3. TURCK USA
www.turck-usa.com
Part No. RB50672-999NW (999=quantity in meters on reel);

E. PROFIBUS® DP™ Festoon Cable
1. Purple color jacket;
2. Red/Green;
3. 2 conductor, twisted, stranded, shield;

F. Acceptable PROFIBUS® DP™ Festoon Cable Manufacturers
1. BELDEN®
www.belden.com
Part No. 3079E;
2. SIEMENS INDUSTRY
www.automation.siemens.com
PROFIBUS® Flexible,
Part No. 6XV1 830-0PH10;
3. TURCK USA
www.turck-usa.com
Part No. RB50672-999NW (999=quantity in meters on reel);

G. PROFINET™ Cable
1. Interior Control Panel Applications:
a. Green color jacket;
b. 8-core Fast Connect installation cables for cabling system with Gigabit capability;
c. Easy stripping with the Fast Connect Stripping Tool; the outer sheath and the braided shield are stripped accurately in one step;
d. Connection to IE FC RJ45 Straight Plug (AWG 24) using insulation-displacement technology;
e. Satisfies Category 6 (Cat6) of the international cabling standards ISO/IEC 11801 and EN 50173;
f. UL approval;

H. Acceptable PROFINET™ Cable Manufacturers
1. SIEMENS INDUSTRY
www.automation.siemens.com
IE FC TP Standard Cable 4x2 (AWG 24),
Part No. 6XV1 878-2E;
2. City Preapproved Equal

I. IEEE 802.3 Ethernet Cable
1. Indoor Applications:
a. Blue color jacket;
b. Eight (8) conductor (4-pair), 23 AWG solid bare copper conductors;
c. Fluorinated Ethylene Propylene (FEP) insulation;
d. Cross-web Separator;
e. Low-smoke, Flame-retardant Polyvinyl Chloride (PVC) jacket;

f. Plenum rated;
g. Pair colors: 1. White/Blue Stripe & Blue, 2. White/Orange Stripe & Orange, 3. White/Green Stripe & Green, 4. White/Brown Stripe & Brown;
h. Applications: up to and including 10 Gigabit Ethernet, 100BaseTX, 100BaseVG ANYLAN, RS-422, Noisy Environments, PoE;

2. Outdoor Applications:
a. Black color jacket;
b. Eight (8) conductor (4-pair), 24 AWG solid bare copper conductors;
c. Polyolefin (PO) insulation;
d. Polyethylene (PE) Unshielded jacket;
e. Pair colors: 1. White/Blue Stripe & Blue, 2. White/Orange Stripe & Orange, 3. White/Green Stripe & Green, 4. White/Brown Stripe & Brown;
f. Applications: up to and including 10 Gigabit Ethernet, 100BaseTX, 100BaseVG ANYLAN, RS-422, PoE;

J. Acceptable IEEE 802.3 Ethernet Cable Manufacturers
1. BELDEN®
www.belden.com
For Indoor Applications:
Part No.10GX13 Multi-Conductor - Enhanced Category 6A Non-bonded-Pair Cable;
2. BELDEN®
www.belden.com
For Outdoor Applications:
Part No.OSP6U Multi-Conductor - Category 6 Non bonded- Pair Outside Plant Cable;
3. City Preapproved Equal

K. CAN Communication Cable
1. Three conductor (CAN LOW, HIGH, GRD);
2. low capacitance computer cable;
3. 20 AWG, Non-Plenum;

L. Acceptable CAN Communication Cable Manufacturers
1. ALPHA WIRE
www.alphawire.com
Part No. 2413C;
2. BELDEN®
www.belden.com
Part No. 8772;
3. City Preapproved Equal

M. RS232 Serial Communication Cable

N. Acceptable RS232 Serial Communication Cable Manufacturers
1. ALPHA WIRE
www.alphawire.com
Part No. 5471C;
2. BELDEN®

www.belden.com
Part No. 9501;

3. City Preapproved Equal

O. RS485 Serial Communication Cable

P. Acceptable RS485 Serial Communication Cable Manufacturers

1. ALPHA WIRE
www.alphawire.com
Part No. 6412;

2. BELDEN®
www.belden.com
Part No. 9841;

3. City Preapproved Equal

Q. Coax 50-Ohm Low Loss Flexible Communication Cable

1. 11 AWG stranded;
2. Single 0.108-inch bare copper conductor;
3. Foam Polyethylene insulation;
4. Bare copper braid shield;
5. Black color non-contaminating PVC jacket;
6. 300V RMS;
7. UL AWM Style 1354;

R. Acceptable Coax 50-Ohm Low Loss Flexible Communication Cable Manufacturers

1. BELDEN®
www.belden.com
RG-8/U Coaxial
Part No. 8214;

2. GENERAL CABLE® CO.
www.generalcable.com
RG-8/U Coaxial
Part No. C1198;

2.4 CONNECTORS

A. Power Conductors: Terminations shall be die type or set screw type pressure connectors as specified and UL Listed for application.

B. Control Conductors: Termination on saddle-type terminals shall be wired directly with a maximum of two conductors per termination. Termination on screw type terminals shall be made with a maximum of two spade connectors.

C. Splices shall not be made in push-button control stations, conduit bodies, control panels, etc.

D. Any 480VAC splice, where approved by the Engineer, shall be compression type with heat shrink boot.

E. Connectors for Aboveground Dry and Damp Locations, #8 AWG and Larger Compression lugs, splices or taps of copper alloy;

F. Acceptable Connectors for Aboveground Dry and Damp Locations, #8 AWG and Larger Manufacturers

1. BURNDY®
www.burndy.com

BURNDY®
YAZ Long Barrel with Inspection Port Copper Compression Lug;
YS Long Barrel Copper Butt Splice Standard;

2. THOMAS & BETTS
www.tnb.com
Color-Keyed® Long Barrel with Inspection Port Copper Compression Lug
Color-Keyed® YS Long Barrel Copper Butt Splice Standard

3. City Preapproved Equal

G. Connectors for Aboveground in Light Poles, and Above or Below Ground In Manholes, Handholes and Pull Boxes

H. Acceptable Connectors for Aboveground in Light Poles, and Above or Below Ground in Manholes, Handholes and Pull Boxes Manufacturers

1. 3M™
www.3m.com
Heat Shrink & Molded Shapes;

2. THOMAS & BETTS
www.tnb.com
Shrink-Kon® Heat Shrinkable Tubing and Splice Insulators & Covers;

3. City Preapproved Equal

I. Connectors for Aboveground, Dry and Damp Locations, #10 AWG and Smaller (aka Wire Nuts);

J. Acceptable Connectors for Aboveground, Dry and Damp Locations, #10 AWG and Smaller (aka Wire Nuts) Manufacturers

1. 3M™
www.3m.com
Scotchlock;

2. IDEAL® INDUSTRIES, INC.
www.idealindustries.com
Twister® PRO Wire Connector;

3. City Preapproved Equal

K. RJ-45 Connector (Plug) - CAT5, Unshielded, 50-micron Clear;

L. Acceptable RJ-45 Connector (Plug) - CAT5, Unshielded, 50-micron Clear Manufacturers

1. BELKIN®
www.belkin.com
For Round Cable,
Part No. R6G088-R-100;
For Flat Cable,
Part No. R6G088-100;

2. City Preapproved Equal

M. RG8/U Coax N Clamp/Solder Connectors

N. Acceptable RG8/U Coax N Clamp/Solder Connector Manufacturers

1. AMPHENOL® CORPORATION
www.amphenolrf.com
Type N Female RG8/U
Part No. 082-209-1006; and

Type N Male RG8/U
Part No. 082-202-1006;

2. RF INDUSTRIES
www.rfindustries.com
Type N Female RG8/U
Part No. RFN-1024-1SI; and
Type N Male RG8/U
Part No. RFN-1002-1SI;

O. RG8/U Coax UHF UG Standard Solder Type Connector

P. Acceptable RG8/U Coax UHF UG Standard Solder Connector Manufacturers

1. AMPHENOL® CORPORATION
www.amphenolrf.com
PL259 UHF Plug,
Part No. 083-822;

2. RF INDUSTRIES
www.rfindustries.com
PL259 UHF Plug,
Part No. RFU-501;

2.5 MISCELLANEOUS WIRE AND CABLE NEEDS

A. Tape - Use as Manufacturer recommended per specific application;

B. Acceptable Tape Manufacturers

1. 3M™
www.3m.com
Part No. 33 - ¾-inch x 66-feet LV Electrical;
Part No. 130C – 1½-inch x 30-feet Linerless Rubber Splice;
Part No. 88 - ¾-inch x 66-feet HV Electrical;
Part No. 88 - 1½-inch x 44-feet Electrical;
Part No. 25 - ½-inch x 15-feet Ground Braid;
Part No. A3 - 1-inch x 75-feet Abrasive;
Part No. 35 - ½-inch x 20-feet Code Brown;
Part No. 35 - ½-inch x 20-feet Code Orange;
Part No. 35 - ½-inch x 20-feet Code Yellow;
Part No. 1755 - ¾-inch x 60-feet Friction;
Part No. 77 - 3-inch x 20-feet Fire Arc Proofing;
Part No. 70 - 1-inch x 30-feet Silicone Rubber;
Part No. 69 - ½-inch x 66-feet Glass cloth;

2. City Preapproved Equal

C. Electrical Insulating Resins - Use per specific and approved application;

D. Acceptable Electrical Insulating Resin Manufacturers

1. 3M™
www.3m.com
Scotchcast™
Electrical Insulating Resin; or
Potting Kit;

2. City Preapproved Equal

E. Seal Air Pad (Putty) - Use per specific and approved application;

F. Acceptable Seal Air Pad (Putty) Manufacturers
   1. COOPER POWER SYSTEMS
      www.cooperpower.com
      Kearney™ Airseal®
      Part No.18415-1
   2. City Preapproved Equal
G. Pulling Lubricant - Use only cable pulling compound that is approved by the Manufacturer of the cable as being compatible with cable insulation and jacket materials. UL Listed;
H. Acceptable Pulling Lubricant Manufacturers
   1. GREENLEE®
      A TEXTRON COMPANY
      www.greenlee.com
      Cable-Gel™ Lubricant;
   2. IDEAL® INDUSTRIES, INC.
      www.idealindustries.com
      Velocity™ Cable Pulling Lubricant;
   3. City Preapproved Equal
I. Cable Ties & Accessories
J. Acceptable Cable Ties & Accessories Manufacturers
   1. PANDUIT®
      www.panduit.com
      Super-Grip™ Cable Ties,
      Weather Resistant Nylon;
   2. THOMAS & BETTS
      www.tnb.com
      Catamount® Cable Ties,
      Ultraviolet Resistant Nylon;
   3. City Preapproved Equal

PART 3 - EXECUTION

3.1 GENERAL

A. Install wires and cables in raceways.
B. Provide a separate insulated grounding conductor in all raceways.
C. Where conductors are to be electrically connected to metallic surfaces, polish the coated surfaces of the metal before installing the connector.
D. All conductors shall be carefully handled to avoid kinks or damage to insulation.
E. All wire and cable shall be continuous and without splices between points of connection to equipment terminals. A splice will be approved by the Engineer if the length required between the points of connection exceeds the greatest standard shipping length available from the Manufacturer specified or approved by the Engineer.
F. Contractor shall seal conduits properly prior to Substantial Completion in the presence of the City or the City's representative, NO EXCEPTIONS.

3.2 PREPARATION

A. Remove debris and moisture from conduits, wireways, boxes and cabinets prior to conductor installation.
B. Do not pull conductors into conduits until all work is suitable for installation of wire or cable.

3.3 INSTALLATION IN CONDUIT

A. Use pulling means, including fish tape, cable, rope and basket weave cable grips which will not damage cables or raceways. Do not use rope hitches as pulling attachment to wire or cable. Steel fish tapes and/or steel pulling cables shall not be used in PVC conduit runs.
B. Pull all conductors to be installed in a conduit together. Train and guide wires into the conduit using a pulling wheel and lubricant.
C. Provide a means of communication between the pulling and guiding points to facilitate installation and to help prevent damage.
D. Lubrications shall be used to facilitate wire pulling. Lubricants shall be UL Listed for use with the insulation specified and be fully removed from conductors immediately after installing conductors.

3.4 CONTROL AND INSTRUMENTATION WIRING

A. Where terminals provided will accept such lugs, terminate control and instrumentation wiring, except solid thermocouple leads, with insulated, locking-fork compression lugs.
B. Terminate with methods consistent with terminals provided, and in accordance with terminal Manufacturer's instructions.
C. All control and instrumentation wiring shall be installed from terminal to terminal with no splicing at any intermediate point.
D. Shielded instrumentation wire shall be installed in dedicated conduit and pull boxes containing only shielded instrumentation cable per the Contract Drawings.
E. Instrumentation cables shall be separated from control cables in manholes and handholes.
F. Shielding on instrumentation cable shall be grounded at one end only, as directed by supplier of the instrumentation equipment and approved by the City’s Industrial Automation Manager.
G. Where connections of cables installed under this section are to be made by others, leave pigtails of adequate length for bundled connections.
H. Cable Protection:
    1. Under Infinite Access Floors: May be installed without bundling;
    2. All Other Areas: Install individual wires, pairs, or triads in flex conduit under the floor or grouped into bundles at least ½ -inch in diameter;
    3. Maintain integrity of shielding of instrumentation cables;
    4. Ensure grounds do not occur because of damage to jacket over the shield;
I. Extra Conductor Length: For conductors to be connected by others, install minimum 6 feet of extra conductor in freestanding panels and minimum 2 feet in other assemblies shall be provided.
J. All communications cable shall be supplied and installed by the Contractor.

3.5 INSTALLATION IN BOXES AND CABINETS

A. Group conductors No. 1/0 and smaller in panelboards, cabinets, pull boxes, and switchboard wireways, tie with plastic ties, and fan out to terminals. Lace conductors 2/0 and larger with appropriate sized plastic ties.
B. Provide sufficient length of conductors within cabinets and cutout boxes to train the conductor to the terminal point with no excess.
C. Terminate wires so that there is no bare conductor at the terminal.

3.6 WIRE SPLICING AND CONNECTING

A. Wire and cable connections to terminals and taps shall be made with compression connectors. Connections of insulated conductors shall be insulated and covered. All connections shall be made using UL Listed materials and installation methods in accordance with instructions and recommendations of the Manufacturer of the particular item of wire and cable. The conductivity of all completed connections shall be not less than that of the uncut conductor. The insulation resistance of all completed connections of insulated conductors shall be not less than that of the uncut conductor.
B. Tighten electrical connections and terminals, including screws and bolts, in accordance with Manufacturer's published torque tightening values. Where Manufacturer's torque requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL 486A-486B.
C. Retighten bolt-type connectors 24 to 48 hours after initial installation and before taping.
D. Tape connections made with non-insulated-type connectors with rubber-type tape, one and one-half times the thickness of the conductor insulation, then cover with Scotch 33 tape or equal.

3.7 SPLICE MARKER

A. Provide concrete marker to indicate location of direct burial cable splice.

3.8 CONDUIT MARKER

A. Provide concrete marker to indicate location of capped end of conduit.

3.9 TESTS

A. Tests shall be made at not less than 1,000 VDC.
B. Test each complete circuit prior to energizing with a meg-ohm meter. The insulation resistance between conductors and between each conductor and ground shall not be less than 25 meg-ohms. Replace wiring of circuits that fail and repeat the test.
C. See Section 16950 - Electrical Testing for additional testing requirements.

3.10 WARRANTY (PROJECT)

A. Equipment Manufacturer warrants that all goods supplied are free of non-conformities in workmanship and materials for one year from date of Substantial Completion.

End of Section

Section 16150

MOTORS

PART 1 - GENERAL

1.1 SCOPE

A. Furnish and install all motors as hereinafter specified and/or as shown on the Contract Drawings. In addition, motors may be called for in other sections of these Specifications.

B. Related Work Specified Elsewhere (if included):
   1. Division 1 – General Requirements;
   2. Division 2 – Site Work;
   3. Division 3 – Concrete;
   4. Division 11 – Equipment;
   5. Division 13 – Special Construction;
   6. Division 15 – Mechanical;
   7. Division 16 – Electrical;

C. Motors provided shall be sufficient size for the duty to be performed and shall not exceed their full-rated load when the driven equipment is operating at specified capacity. Unless otherwise noted, motors driving pumps shall not be overloaded at any head or discharge condition of the pump.

1.2 REFERENCES

A. All characteristics, definitions, and terminology, except as specifically covered in this Specification, shall be in accordance with the latest revision of the following standards:
   1. Anti-Friction Bearing Manufacturers Association (AFBMA) 9 - Load Ratings and Fatigue Life for Ball Bearings;
   2. AFBMA 11 - Load Rating and Fatigue Life for Roller Bearings;
   3. American National Standards Institute (ANSI) C50.41 - Polyphase Induction Motors for Power Generating Stations;
   4. Institute of Electrical and Electronics Engineers (IEEE) 85 - Test Procedure for Airborne Sound Measurements on Rotating Machines;
   5. IEEE 112 - Standard Test Procedures for Polyphase Induction Motors and Generators;
   6. IEEE 114 - Standard Test Procedures for Single-Phase Induction Motors;
   7. IEEE 620 - Guide for Construction and Interpretation of Thermal Limit Curves for Squirrel-Cage Motors Over 500 Horsepower;
   8. IEEE 841™ - The Petroleum and Chemical Industry-Severe Duty Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors-Up to and Including 500HP;
   9. National Electrical Contractors Association (NECA) National Electrical Installation Standards (NEIS);
   10. NECA 1 - Standard Practice of Good Workmanship in Electrical Construction;

11. NECA 230 - Standard for Selecting, Installing, and Maintaining Electric Motors and Motor Controllers;
12. National Fire Protection Association® (NFPA®) 70 – National Electrical Code® (NEC®);
13. National Electrical Manufacturers Association (NEMA) Premium™ Product Scope and Nominal Efficiency Levels;
14. NEC® Article 430 – Motors, Motor Circuits and Controllers;
15. NEMA MG 1 – Motors and Generators;
16. NEMA MG 13 - Frame Assignments for Alternating Current Integral Horsepower Induction Motors;
17. NEMA 250 - Enclosures for Electrical Equipment (1,000 Volts Maximum);
18. NFPA® 70E® - Electrical Safety in the Workplace;
19. Underwriters Laboratories (UL) 547 - Thermal Protectors for Electric Motors.
20. UL 674 - Electric Motors and Generators for Use in Hazardous (Classified) Locations;
21. UL 1004-1 - Rotating Electrical Machines - General Requirements;
22. UL 1004-2 - Impedance Protected Motors;
23. UL 1004-3 - Thermally Protected Motors;
24. UL 1004-7 - Electronically Protected Motors;
25. UL 1004-8 - Inverter Duty Motors;

1.3 SUBMITTALS

A. Submit shop drawings in accordance with the General Conditions and Section 01420.

B. All submittal documents shall be provided in both hardcopy, bounded in separate three-ring binders, indexed, tabbed with sectional dividers, and no larger than 8½-inch x 11-inch and bookmarked electronic media - Adobe® Acrobat® portable document format. Two sets of hardcopy and two sets of electronic media shall be provided.

C. All drawings shall be provided in both hardcopy, bounded, indexed, and no larger than 11-inch x 17-inch and bookmarked electronic media - Autodesk® AutoCAD® file format AND Adobe® Acrobat® portable document format. Two sets of hardcopies and two sets of electronic media shall be provided.

D. The Motor Manufacturer shall submit to the Engineer certified dimension prints showing nameplate data and outline dimensions within three (3) weeks of the date they receive the order.

E. The following information, at a minimum, shall be submitted to the City:
   1. Descriptive bulletins;
   2. Product data sheets;
   3. Master drawing index;
   4. Dimensioned front & plan view of the assembly;
   5. Schematic diagram;
   6. Descriptive information;
   7. Nameplate data in accordance with NEMA MG 1;

8. Additional Rating Information:
    a. Service factor;
    b. Locked rotor current;
    c. No load current;
    d. Safe stall time for motors 200HP and larger;
    e. Multi-speed load classification (e.g., variable torque);
    f. Adjustable frequency drive motor load classification (e.g., variable torque) and minimum allowable motor speed for that load classification;
9. Enclosure type and mounting (e.g. horizontal, vertical);
10. Dimensions and total weight.
11. Conduit box dimensions and usable volume as defined in NEMA MG 1 and NFPA 70.
12. Bearing type.
13. Bearing lubrication.
14. Bearing life.
15. Space heater voltage and watts.
16. Description and rating of motor thermal protection.
17. Motor sound power level in accordance with NEMA MG 1.
18. Maximum brake horsepower required by the equipment driven by the motor.
19. Description and rating of submersible motor moisture sensing system.
20. Provide letter stating that motors are suitable for VFD operation.
21. Motor Full Load Current (Amps). Cable terminal sizes;
22. Component list;
23. Wiring diagrams;
24. Installation information;

F. The Motor Manufacturer shall provide a minimum five (5) year warranty letter in their submittal.

1.4 QUALITY ASSURANCE

A. The Manufacturer shall have a minimum of ten (10) years consecutive experience producing similar electrical equipment.
B. The Manufacturer shall be ISO certified.
C. UL Listing Requirements –
    1. “Manufactured in accordance with” is not equivalent to “UL LISTED” and does not meet the intent of this specification;
    2. The Motor shall be posted at www.UL.com under Category Code “PRGY“ and/or “PRHJ” for inverter-duty rated; Products without posting at UL.com shall not be approved. To access UL Category Code, click on Certifications of UL’s home page. Type “PRGY“ and/or “PRHJ” into the Category Code search box and click Search;

1.5 DELIVERY, STORAGE AND HANDLING

A. Deliver products and equipment in factory labeled packages that include recommended storage practices placed on the outside of the shipping container.

B. Handling and shipment of the products and equipment shall be in such a manner to prevent internal component damage, breakage, and denting and scoring of the enclosure finish.
C. Store and handle in strict compliance with Manufacturer's instructions and recommendations. Protect from potential damage from weather and construction operations. Store so condensation will not form on or in equipment and if necessary, apply temporary heat where required to obtain suitable service conditions.

PART 2 - PRODUCTS

2.1 GENERAL

A. All motors to be installed outdoors, exposed to the weather, shall be suitable for continuous operation in 110 ºF (43 ºC) ambient temperature; These motors shall be Totally Enclosed Fan Cooled (TEFC), Weather-Protected Type II (WPII); unless otherwise specified;
B. All motors to be installed indoors shall be suitable for continuous operation in 125 ºF (52 ºC) ambient temperature; These motors shall be Totally Enclosed Fan Cooled (TEFC), Weather-Protected Type I (WPI); unless otherwise specified;
C. Unless otherwise specified, electrical motors shall be provided by the Manufacturer and built in accordance with UL 674, UL 1004, and NEMA MG 1. D. All motors above one (1) horsepower (HP) shall meet or exceed IEEE 841 and NEMA Premium™ standard efficiency levels contained in NEMA Standards Publication MG 1 Tables 12-12 and 12-13;
D. All motors to be operated with variable frequency drives (VFDs) shall state they are suitable for their intended application. These motors' nameplates shall bear "Inverter Duty Rated". In addition, VFD motors shall meet the requirements of NEMA MG 1, Part 31 - Definite-Purpose Inverter-Fed Polyphase Motors;
E. All motors weighing over 50-pounds shall be fitted with at least one (1) lifting ring or "O' type bolt;
F. All motor enclosures shall have stainless steel screens;
G. All motors shall be protected from corrosion, fungus and insects;
H. All motors and equipment shall be bonded to the equipment grounding system;
I. Refer to Section 11000 for motor efficiencies.

2.2 RATINGS

A. All motors shall be of the low voltage type and adhere to the following power ratings:
    1. All below ½ HP motors shall be rated 115/230VAC, 1-phase, 60-Hertz;
    2. All ½ HP through 100 HP motors shall be rated 230/460VAC, 3-phase, 60-Hertz;
    3. All 125 HP through 800 HP motors shall be 460VAC, 3-phase, 60-Hertz;
B. All 10 HP and larger motors shall have a 120VAC space heater installed for moisture control;

C. All 100 HP and larger motors and/or any VFD controlled motor shall have a thermistor type winding temperature switch, at a minimum;
D. All 275 HP and larger motors shall have platinum-100 RTDs (2 per phase in the windings and 1 each on the bearings) and two vibration sensor transmitters, at a minimum;

2.3 FRAMES

A. Aluminum frame motors shall not be allowed;
B. Steel frame motors shall be permitted with motor frames 184 and smaller;
C. Cast iron for motor frames 184 and larger shall be provided;

2.4 NAMEPLATES

A. All motor nameplates shall be permanently fastened to the motor frame and be positioned for easy visibility;
B. Motor nameplates shall be stamped stainless steel and include those items enumerated in NEMA Standard MG 1;
C. Nameplates for high efficiency motors shall list the nominal efficiency;
D. Nameplates for explosion-proof motors shall indicate frame temperature limit code;

2.5 FRACTIONAL HORSEPOWER MOTORS

A. Fractional horsepower motors shall be rigid, welded steel, designed to maintain accurate alignment of motor components and provide adequate protection.
B. End shields shall be reinforced, lightweight die-cast aluminum.
C. Windings shall be of varnish-insulated wire with slot insulation of polyester film, baked-on bonding treatment to make the stator winding strongly resistant to heat, aging, moisture, electrical stresses and other hazards;
D. Motor shaft shall be made from high-grade, cold-rolled shaft steel with drive-shaft extensions carefully machined to standard NEMA dimensions for the particular drive connection;
E. For light to moderate loading, bearings shall be quiet all-angle sleeve type with large oil reservoir that prevents leakage and permits motor operation in any position;
F. For heavy loading, bearings shall be carefully selected precision ball bearings with extra quality, long-life grease, and large reservoir providing 10-years normal operation without additional lubrication;

2.6 SINGLE-PHASE MOTORS

A. Single-phase motors shall be split-phase and capacitor-start induction types rated for continuous horsepower at the RPM called for on the Contract Drawings; Motors shall be rated 115/230VAC, single-phase 60-Hertz, open drip-proof, or totally enclosed fan cooled with Class B Insulation;
B. Totally Enclosed Fan Cooled (TEFC) motors shall be designed for severe-duty;
C. Motors shall have corrosion and fungus protective finish on internal and external surfaces; All fittings shall have corrosion protective plating;

D. Mechanical characteristics shall be the same as specified for polyphase fractional horsepower motors;

2.7 THREE-PHASE MOTORS

A. Motors shall be of the squirrel-cage or would rotor induction type; Horizontal, vertical solid-shaft, vertical hollow-shaft, normal thrust or high-thrust shall be furnished as specified;
B. All motors shall have normal or high starting torque (as required), low starting current (not to exceed 600% FLA), and low slip;
C. All motors shall have a 1.15 Service Factor and Class H Insulation;
D. All motors shall be suitable for operation in moist air with hydrogen sulfide gas present;
E. The output shaft shall be suitable for direct connection or belt-drive as required;
F. All interior and exterior surfaces of motors shall have a final coating of chemical resistant corrosion and fungus protective epoxy fortified enamel finish spray over red primer applied; Stator bore and rotor of all motors shall be epoxy coated;
G. All fittings, bolts, nuts and screws shall be Type 316 stainless steel; Bolts and nuts shall have hex heads;
H. All machine surfaces shall be coated with rust inhibiter for easy disassembly;
I. All conduit boxes shall be oversized, if offered, and supplied with a petroleum resistant gasket; In addition, lead wires between motor frame and conduit box shall be supplied with a petroleum resistant gasket;
J. Totally enclosed motors shall be provided with condensate drain hole and epoxy coated motor windings to protect against moisture;
K. Motor frames and end shields shall be cast iron or heavy fabricated steel of such design and proportions as to hold all motor components rigidly in proper position and provide adequate protection for the type of enclosure employed;
L. Windings shall be adequately insulated and securely braced to resist failure due to electrical stresses and vibrations;
M. The shaft shall be made of high-grade machine steel or steel forging of size and design adequate to withstand the load stresses normally encountered in motors of the particular rating. Bearing journals shall be ground and polished;
N. Rotors shall be made from high-grade steel laminations adequately fastened together and to the shaft; Rotor squirrel-cage windings may be cast-aluminum or bar-type construction with brazed end rings;
O. Motors shall be equipped with vacuum-degassed anti-friction bearings made to AFBMA Standards and be of ample capacity for the motor rating; The bearing housing shall be large enough to hold sufficient lubricant to minimize the need for frequent lubrication, but facilities shall be provided for adding new lubricant and draining old lubricant without motor disassembly; The bearing housing shall have long, tight, running fits or rotating seals to

protect against the entrance of foreign matter into the bearings, or leakage of lubricant out of the bearing cavity;

P. Bearings of high-thrust motors shall be locked for momentary up-thrust of 30% down-thrust; All bearings shall have a minimum B10 life rating of 100,000-hours in accordance with AFBMA life and thrust values;

Q. Vertical hollow-shaft motors shall have non-reverse ratchets to prevent backspin;

2.8 ACCEPTABLE MOTOR MANUFACTURERS

A. The listing of specific Manufacturers does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed are not relieved from meeting these specifications in their entirety.

1. ABB, INC.
   BALDOR ELECTRIC COMPANY
   www.abb.com
   www.baldor.com
   Super-E®
   Premium Efficiency Series;
2. NIDEC MOTOR CORPORATION
   www.nidec-motor.com
   U.S. Motors® 841 PLUS®;
3. SIEMENS INDUSTRY
   www.sea.siemens.com
   Severe & Inverter Duty Series;

PART 3 - EXECUTION

3.1 INSTALLATION

A. All motors shall be connected to the conduit system by means of a short section (minimum 18-inch) of flexible conduit unless otherwise indicated; For all motor connections, the CONTRACTOR shall install a grounding conductor in the conduit and terminate at the motor control center with an approved grounding clamp;

3.2 ADJUSTING AND CLEANING

A. The motors shall be adjusted accordingly per Manufacturer's recommendations.

B. Clean exposed surfaces using Manufacturer recommended materials and methods.

C. Vacuum all interior spaces.

3.3 TESTING

A. The following tests shall be performed on all motors after installation, but before placing the motors in service;

B. The CONTRACTOR shall megger each motor winding before energizing the motor, and if insulation resistance is found to be low, shall notify the Engineer and shall not energize the motor;

C. The following table gives minimum acceptable insulation resistance in meg-ohms at various temperatures and for various voltages with readings being taken after one minute of megger test run:

Degree Winding Temperature	Degree Winding Temperature	Voltage	Voltage	Voltage	Voltage
ºF	ºC	115VAC	230VAC	460VAC	4,160VAC
37	3.9	60	108	210	1,700
50	10	32	60	120	1,000
68	20	13	26	50	460
86	30	5.6	11	21	195
104	45	2.4	4.5	8.8	84
122	50	1	2	3.7	35
140	60	0.5	0.85	1.6	15

D. The CONTRACTOR shall check all motors for correct clearances, alignment and lubrication; If lubrication is low, the CONTRACTOR shall add lubricate per Manufacturer's instructions;
E. The CONTRACTOR shall check direction of rotation of all motors and reverse connections at the conduit box, if necessary;
F. All motors shall be given the standard short commercial test prior to shipment; This test shall consist of no-load current; check current balance; winding resistance; air gap measurement; high potential tests and bearing inspection; Six (6) hard-copies and one (1) electronic copy in Adobe Acrobat Portable Document Format (PDF) of the certified short commercial test shall be sent to the Engineer prior to shipment;
G. Perform factory and installation tests in accordance with applicable NEC®, NEMA and UL requirements.

3.4 STARTUP SERVICES

A. Engage a factory-authorized service representative to perform startup service.
B. Train City's maintenance personnel on procedures and schedules for energizing and de-energizing, troubleshooting, servicing and maintaining equipment and schedules.
C. Verify that all motors are installed and connected according to the Contract Documents.
D. Verify that electrical control wiring installation complies with Manufacturer's submittal by means of point-to-point continuity testing.
E. Verify that wiring installation complies with requirements in Division 16 Sections.
F. Complete installation and startup checks according to Manufacturer's written instructions.

3.5 WARRANTY (PURCHASE ONLY)

A. Motor Manufacturer warrants that all goods supplied are free of non-conformities in workmanship and materials for a minimum of five (5) years from date of Substantial Completion.

3.6 WARRANTY (PROJECT)

A. All equipment furnished and installed under this Section shall be guaranteed against detects of workmanship, materials and improper installation for a period of one (1) year from Substantial Completion. Any such equipment or parts proven defective, due to the above noted causes, shall be replaced by the CONTRACTOR at no cost to the City.

B. Motor Manufacturer warrants that all goods supplied are free of non-conformities in workmanship and materials for a minimum of five (5) years from date of Substantial Completion.

End of Section

Section 16160

PANELBOARDS

PART 1 - GENERAL

1.1 SCOPE

A. Contractor shall furnish all labor, materials, equipment and incidentals required and install all panelboards as hereinafter specified and as shown on the Contract Drawings.

B. Related Work Specified Elsewhere (if included):

1. Division 1 – General Requirements;
2. Division 2 – Site Work;
3. Division 3 – Concrete;
4. Division 11 – Equipment;
5. Division 13 – Special Construction;
6. Division 15 – Mechanical;
7. Division 16 – Electrical;

1.2 REFERENCES

A. All characteristics, definitions, and terminology, except as specifically covered in this Specification, shall be in accordance with the latest revision of the following standards:

1. American National Standards Institute (ANSI) / Underwriters Laboratories (UL) 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations;
2. ANSI/UL 50E - Enclosures for Electrical Equipment, Environmental Considerations;
3. ANSI/UL 67 – Panelboards;
4. ANSI/UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures;
5. ANSI/UL 508A - Industrial Control Equipment;
6. ANSI/UL 1449 - Surge Protective Devices (3rd edition);
7. ANSI/UL 1053 - Ground-Fault Sensing and Relaying Equipment;
8. National Electrical Contractors Association (NECA) National Electrical Installation Standards (NEIS);
9. NECA 1 - Standard Practice of Good Workmanship in Electrical Construction;
10. NECA 407 - Recommended Practice for Installing and Maintaining Panelboards;
11. National Electrical Code (NEC®) 240 – Overcurrent Protection;
12. National Electrical Manufacturers Association (NEMA) Standard PB 1 - Panelboards;
13. National Fire Protection Association® (NFPA®) 70 – National Electrical Code® (NEC®);
14. NEC® Article 250 – Grounding and Bonding;
15. NEC® Article 285 – Surge-Protective Devices (SPDs), 1kV or Less;

16. NEC® Article 312 – Cabinets, Cutout Boxes, and Meter Socket Enclosures;
17. NEC® Article 314 – Outlet, Device, Pull, and Junction Boxes; Conduit Bodies; Fittings; and Handhold Enclosures;
18. NEC® Article 404 – Switches;
19. NEC® Article 408 – Switchboards and Panelboards;
20. NFPA® 70E® - Electrical Safety in the Workplace;

1.3 SUBMITTALS

A. Submit shop drawings in accordance with the General Conditions and Section 01420.
B. All submittal documents shall be provided in both hardcopy, bounded in separate three-ring binders, indexed, tabbed with sectional dividers, and no larger than 8½-inch x 11-inch and bookmarked electronic media - Adobe® Acrobat® portable document format. Two sets of hardcopy and two sets of electronic media shall be provided.
C. All drawings shall be provided in both hardcopy, bounded, indexed, and no larger than 11-inch x 17-inch and bookmarked electronic media - Autodesk® AutoCAD® file format AND Adobe® Acrobat® portable document format. Two sets of hardcopy and two sets of electronic media shall be provided.
D. The following information, at a minimum, shall be submitted to the City:
   1. Descriptive bulletins;
   2. Product data sheets;
   3. Master drawing index;
   4. Dimensioned front & plan view of the assembly;
   5. Schematic diagram;
   6. Bus connection;
   7. Connection details;
   8. Cable terminal sizes;
   9. Component list;
   10. Conduit space entry/exit locations;
   11. Wiring diagrams;
   12. Installation information;

1.4 QUALITY ASSURANCE

A. The Manufacturer shall have a minimum of ten (10) years consecutive experience producing similar electrical equipment.
B. The Manufacturer shall be ISO certified.
C. UL Listing Requirements –
   1. “Manufactured in accordance with” is not equivalent to “UL LISTED” and does not meet the intent of this specification;
   2. The Panelboard shall be posted at www.UL.com under Category Code “QEUY“, “QFIW”, “QFKR” and/or “QFOF”. Products without posting at UL.com shall not be approved. To access UL Category Code, click on Certifications of UL’s home page. Type “QEUY“, “QFIW”, “QFKR” and/or “QFOF” into the Category Code search box and click Search.

1.5 DELIVERY, STORAGE AND HANDLING

A. Deliver products and equipment in factory labeled packages that include recommended storage practices placed on the outside of the shipping container.
B. Handling and shipment of the products and equipment shall be in such a manner to prevent internal component damage, breakage, and denting and scoring of the enclosure finish.
C. Store and handle in strict compliance with Manufacturer's instructions and recommendations. Protect from potential damage from weather and construction operations. Store so condensation will not form on or in equipment and if necessary, apply temporary heat where required to obtain suitable service conditions.

PART 2 - PRODUCTS

2.1 RATINGS

A. Panelboard ratings shall be as shown on the Contract Drawings. All panelboards shall be rated for the intended voltage, environment and application. All panelboards shall have a copper bus; bolt-in type circuit breakers with grounding and lug kits and integral surge protection device.
B. Panelboards and bolt-in type circuit breakers shall be suitable for use with 167 °F (75 °C) wire at full NFPA® 70, 167 °F (75 °C) ampacity.
C. Short-Circuit Current Equipment Rating shall be fully rated. Series connected is unacceptable to the City.
D. Minimum ratings applicable with available short-circuit current of 25,000 amperes RMS symmetrical at 208Y/120VAC or 120/240VAC and 65,000 amperes RMS symmetrical at 480Y/277VAC.
E. Where ground fault interrupter circuit breakers are indicated or required by code, these breakers shall be 5 mA trip, 10,000 amps interrupting capacity circuit breakers.
F. F. All panelboards provided shall provide a minimum of six (6) spare circuit spaces for future expansion.

2.2 SINGLE MANUFACTURER

A. The Manufacturer of the panelboards, bolt-in type circuit breakers with grounding and lug kits and integral surge protection device shall be the same Manufacturer.

2.3 CONSTRUCTION (NEMA 1 AND NEMA 4X)

A. Interiors
    1. All interiors shall be completely factory assembled with circuit breakers, wire connectors, etc. All wire connectors, except screw terminals, shall be of the anti-turn solder-less type and all shall be suitable for copper wire of the sizes indicated;
    2. Interiors shall be so designed that circuit breakers can be replaced without disturbing adjacent units and without removing the main bus connectors and shall be so designed that circuits may be changed without machining, drilling or tapping;

3. Branch circuits shall be arranged using double row construction. Branch circuits shall be numbered by the Manufacturer.
4. A nameplate shall be provided listing panel type, number of circuit breakers and ratings;

B. Buses
1. Bus bars for the mains shall be of copper. Full size neutral bars shall be included. Bus bar taps for panels with single pole branches shall be arranged for sequence phasing of the branch circuit devices. Bussing shall be braced throughout to conform to industry standard practice governing short circuit stresses in panelboards. Phase bussing shall be full height without reduction. Cross connectors shall be copper.
2. Neutral bussing shall have a suitable lug for each outgoing feeder requiring a neutral connection.
3. Spaces for future circuit breakers shall be bussed for the maximum device that can be fitted into them.
4. Buses for 480V panelboards shall be rated for 65,000 amperes RMS symmetrical. Buses for 120/208V light panels shall be rated 10,000 amperes RMS symmetrical.

C. Surge Protection Devices (SPDs)
1. All panelboards shall include integral bus mounted surge protection devices per Section 16709 -Protectors and Surge Protection Devices.

D. Boxes
1. NEMA 1 – Inside, non-corrosive areas features:
   a. Surface mounted boxes shall have an internal and external finish as specified in Section 16160.2.03.E.6.
   b. At least four (4) interior mounting studs shall be provided.
   c. All conduit entrances shall be field punched;
2. NEMA 4X – Corrosive and outside areas features:
   a. Panelboard shall be contained within a Type 316 Stainless Steel enclosure with continuous hinge and three-point latch;
   b. The three-point latch handle shall accept a 2 x 3/8-inch diameter shackle padlock;
   c. Door circuit directory frame and card having a transparent cover shall be furnished on each door;
   d. All conduit entrances shall be field punched.

E. Trim for NEMA 1 Panelboards Only
1. Hinged doors covering all circuit breaker handles shall be included in all panel trims.
2. Doors shall have semi flush type cylinder lock and catch, except that doors over 48-inches in height shall have a vault handle and 3-point latch complete with lock, arranged to fasten door at top, bottom and center. Door hinges shall be concealed;
3. Door circuit directory frame and card having a transparent cover shall be furnished on each door;
4. Lock shall be YALE Cabinet Lock Model No. 511S, keyed to YALE Key No. 47; Two keys shall be supplied for each lock; All locks shall be keyed alike;

5. The trims shall be fabricated from code gauge sheet steel.
6. All exterior and interior steel surfaces of the panelboard shall be properly cleaned and finished with ANSI Z55.1, No. 61 light gray paint over rust inhibiting phosphatized coating. The finish paint shall be of a type to which field applied paint will adhere.
7. Trims for flush panels shall overlap the box by at least ¾-inch all around. Surface trims shall have the same width and height as the box. Trims shall be fastened with quarter turn clamps.

F. Circuit Breakers
1. Panelboards shall be equipped with circuit breakers with frame size and trip settings as shown on the Drawings.
2. Meets UL 489 which incorporates NEMA AB 1;
3. Thermal-magnetic, quick-make, quick-break, molded case, of the indicating type showing ON/OFF and TRIPPED positions of operating handle
4. Non-interchangeable, in accordance with NFPA® 70
5. Provisions for handle padlocking, unless otherwise shown
6. Circuit breakers shall be molded case, bolt-in type ONLY – NO EXCEPTIONS;
7. Multi-pole circuit breakers designed to automatically open all poles when an overload occurs on one pole;
8. Do not substitute single-pole circuit breakers with handle ties for multi-pole breakers
9. Do not use tandem or dual circuit breakers in normal single-pole spaces
10. Circuit breakers used in 120/240VAC and 120/208VAC panelboards shall have an interrupting capacity of not less than 10,000 amperes, RMS symmetrical.
11. Three pole breakers used in 480VAC panelboards shall have an interrupting capacity of not less than 65,000 amperes RMS symmetrical.
12. GFCI (ground fault circuit interrupter) shall be provided for circuits where indicated on the Contract Drawings. GFCI units shall be 1-pole, 120VAC, molded case, bolt on breakers, incorporating a solid state ground fault interrupter circuit insulated and isolated from the breaker mechanism. The unit shall be UL Listed Class A Group I device (5 milliamp sensitivity, 25 millisecond trip time), and an interrupting capacity of 10,000 amperes RMS.

2.4 ACCEPTABLE PANELBOARD MANUFACTURERS

A. The listing of specific Manufacturers does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed are not relieved from meeting these specifications in their entirety.
1. EATON CORPORATION
www.eaton.com
CUTLER-HAMMER®

Pow-R-Line (PRL) 1a, 2a, 3a, 3E and 4 Series with SPD Series Integrated Unit;
PRL1a = 400A Max Main; 400A Main Lugs Only; 480Y/277VAC Max, 3Ø3W, 3Ø4W,1Ø2W, 1Ø3W;
PRL2a = 400A Max Main; 400A Main Lugs Only; 480Y/277VAC Max, 3Ø3W, 3Ø4W,1Ø2W, 1Ø3W;
PRL3a = 600A Max Main; 800A Main Lugs Only; 600VAC Max, 3Ø3W, 3Ø4W, 1Ø2W, 1Ø3W;
PRL3E = 480A Max Main; 600A Main Lugs Only; 600VAC Max, 3Ø3W, 3Ø4W, 1Ø2W, 1Ø3W;
PRL4 = 1200A Max Main; 1200A Max Main Switch; 1200A Max Main Lugs; 600VAC, 3Ø3W, 3Ø4W, 1Ø3W;
SPD with Surge Counter;

2. SIEMENS INDUSTRY
www.sea.siemens.com
Type P1, P2, P3, P4 and P5 Series with Integral Sentron® Transient Protection System (TPS3);
P1 = 400A Max Main; 400A Main Lugs Only; 480Y/277VAC Max, 3Ø3W, 3Ø4W,1Ø2W, 1Ø3W;
P2 = 600A Max Main; 600A Main Lugs Only; 600VAC Max, 3Ø3W, 3Ø4W, 1Ø2W, 1Ø3W;
P3 = 600A Max Main; 800A Main Lugs Only; 600VAC Max, 3Ø3W, 3Ø4W, 1Ø2W, 1Ø3W;
P4 = 800A Max Main; 1200A Max Main Lugs Only; 600VAC, 3Ø3W, 3Ø4W, 1Ø3W;
P5 = 1200A Max Main; 1200A Max Main Switch; 1200A Max Main Lugs; 600VAC, 3Ø3W, 3Ø4W, 1Ø3W;
TPS3 with Surge Counter;

3. **SQUARE D**
Type NQ (QOB) Series with SPD Series Integrated Unit;
I-Line=400A Max Main; 400A Main Lugs Only; 480Y/277VAC Max, 3Ø3W, 3Ø4W, 1Ø2W, 1Ø3W;
I-Line = 400A Max Main; 400A Main Lugs Only; 480Y/277VAC Max, 3Ø3W, 3Ø4W, 1Ø2W, 1Ø3W;
I-Line = 600A Max Main; 800A Main Lugs Only; 600VAC Max, 3Ø3W, 3Ø4W, 1Ø2W, 1Ø3W;
I-Line 480A Max Main; 600A Main Lugs Only; 600VAC Max, 3Ø3W, 3Ø4W, 1Ø2W, 1Ø3W;
I-Line 1200A Max Main; 1200A Max Main Switch; 1200A Max Main Lugs; 600VAC, 3Ø3W, 3Ø4W,1Ø3W;
SPD with Surge Counter.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Boxes for surface mounted panelboards shall be mounted so there is at least ½- inch air space between the box and the wall.

B. Unless otherwise noted on the Contract Drawings, top of cabinets shall be mounted 6-feet, 0-inch above the floor, properly aligned and adequately supported independently of the connecting raceways.
C. All wiring in panelboards shall be neatly formed, grouped, laced, and identified to provide a neat and orderly appearance.
D. A typed directory card identifying all circuits shall be placed in the cardholder inside the front cover. Electronic file(s) in either Microsoft® Word® (.doc or .docx format) or Excel® (.xls or .xlsx format) shall be delivered with the as-built files prior to Substantial Completion.

3.2 ADJUSTING AND CLEANING

A. The panelboards shall be adjusted accordingly per Manufacturer's recommendations.
B. Clean exposed surfaces using Manufacturer recommended materials and methods.
C. Vacuum all interior spaces.

3.3 TESTING

A. Perform factory and installation tests in accordance with applicable NEC®, NEMA and UL requirements.

3.4 STARTUP SERVICES

A. Engage a factory-authorized service representative to perform startup service.
B. Train City's maintenance personnel on procedures and schedules for energizing and de-energizing, troubleshooting, servicing and maintaining equipment and schedules.
C. Verify that all panelboards are installed and connected according to the Contract Documents.
D. Verify that electrical control wiring installation complies with Manufacturer's submittal by means of point-to-point continuity testing.
E. Verify that wiring installation complies with requirements in Division 16 Sections.
F. Complete installation and startup checks according to Manufacturer's written instructions.

3.5 WARRANTY (PURCHASE ONLY)

A. Equipment Manufacturer warrants that all goods supplied are free of non-conformities in workmanship and materials for one year from date of initial operation, but not more than eighteen months from date of shipment.

3.6 WARRANTY (PROJECT)

A. Equipment Manufacturer warrants that all goods supplied are free of non-conformities in workmanship and materials for one year from date of Substantial Completion.

End of Section

Section 16190

SUPPORTING DEVICES

PART 1 - GENERAL

1.1 SCOPE

A. This section includes materials and installation of supporting devices to securely support electrical items from building structures by means of hangers, supports, anchors, sleeves, inserts seals and associated fastenings.

B. Related Work Specified Elsewhere (if included):

1. Division 1 – General Requirements;
2. Division 2 – Site Work;
3. Division 3 – Concrete;
4. Division 11 – Equipment;
5. Division 13 – Special Construction;
6. Division 15 – Mechanical;
7. Division 16 – Electrical;

1.2 REFERENCES

A. All characteristics, definitions, and terminology, except as specifically covered in this Specification, shall be in accordance with the latest revision of the following standards:

1. American National Standards Institute (ANSI) / Underwriters Laboratories (UL);
2. National Electrical Contractors Association (NECA) National Electrical Installation Standards (NEIS);
3. NECA 1 - Standard Practice of Good Workmanship in Electrical Construction;
4. National Fire Protection Association® (NFPA®) 70 – National Electrical Code® (NEC®);
5. NFPA® 70E® - Electrical Safety in the Workplace;
6. UL 5B - Strut-Type Channel Raceways and Fittings;

1.3 SUBMITTALS

A. Submit shop drawings in accordance with the General Conditions and Section 01420.

B. All submittal documents shall be provided in both hardcopy, bounded in separate three-ring binders, indexed, tabbed with sectional dividers, and no larger than 8½-inch x 11-inch and bookmarked electronic media - Adobe® Acrobat® portable document format. Two sets of hardcopy and two sets of electronic media shall be provided.

C. All drawings shall be provided in both hardcopy, bounded, indexed, and no larger than 11-inch x 17-inch and bookmarked electronic media - Autodesk® AutoCAD® file format AND Adobe® Acrobat® portable

document format. Two sets of hardcopy and two sets of electronic media shall be provided.

D. Contractor shall submit product data for each type of product specified.
E. Contractor shall submit shop drawings for supplementary framing. Show design loads, member sizes and locations.

1.4 QUALITY ASSURANCE

A. "Manufactured in accordance with" is not equivalent to "UL LISTED" and does not meet the intent of this specification;
B. The Supporting Devices shall be posted at www.UL.com under the appropriate Category Code; Products without posting at UL.com shall not be approved. To access UL Category Code, click on Certifications of UL's home page. Type the appropriate code into the Category Code search box and click Search;

1.5 DELIVERY, STORAGE AND HANDLING

A. Deliver products and equipment in factory labeled packages that include recommended storage practices placed on the outside of the shipping container.
B. Handling and shipment of the products and equipment shall be in such a manner to prevent internal component damage, breakage, and denting and scoring of the enclosure finish.
C. Store and handle in strict compliance with Manufacturer's instructions and recommendations. Protect from potential damage from weather and construction operations. Store so condensation will not form on or in equipment and if necessary, apply temporary heat where required to obtain suitable service conditions.

PART 2 - PRODUCTS

2.1 GENERAL

A. Protect supports, support hardware, and fasteners with zinc coating or with treatment of equivalent corrosion resistance using reviewed alternate treatment, finish, or inherent material characteristic.
B. Contractor shall choose material and finish compatible with other metal in area (i.e. stairs, grating, air ducts, etc.).

2.2 HANGERS, STRAPS AND BEAM CLAMPS

A. Hangers shall be Type 316 stainless steel;
B. One-hole and two-hole straps shall be Type 316 stainless steel with "Clamp Backs";
C. Beam clamps shall be Malleable iron, hot-dipped galvanized;
D. Acceptable Hanger, Strap and Beam Clamp Manufacturers
   1. EGS ELECTRICAL GROUP
      www.egseg.com
      www.o-zgedney.com
      O-Z/GEDNEY Brand;
   2. THOMAS AND BETTS CO.

www.tnb.com
STEEL CITY® Brand;
KINDORF® Brand;
OR
SUPERSTRUT® Brand;

3. City Preapproved Equal

2.3 SUPPORT & FRAMING CHANNELS AND FITTINGS

A. Channels for Dry, Wet and Corrosive Areas shall be Type 316 stainless steel, 12-gauge minimum;
B. Fittings shall be Type 316 stainless steel;
C. All installations shall include protective end caps;
D. Acceptable Support & Framing Channel and Fitting Manufacturers
   1. ATKORE INTERNATIONAL
      www.unistrut.com
      UNISTRUT® CORP.
      P1000T Series;
   2. COOPER B-LINE®
      www.cooperbline.com
      Strut Systems & Bolted Framing Products, B22SH SS6 Series;
   3. City Preapproved Equal

2.4 ANCHORS

A. Mechanical anchoring systems shall be Type 316 stainless steel self-drilling and expansion bolt types;
B. Acceptable Anchor Manufacturers
   1. ITW RED HEAD (formerly (ITT) PHILLIPS DRILL CO.)
      www.itw-redhead.com
      RED HEAD® Products;
   2. POWERS FASTENERS INC. (formerly RAWL PRODUCTS CO.)
      www.powers.com
      POWERS Products;
   3. City Preapproved Equal

2.5 HARDWARE

A. All Hardware shall be Type 316 stainless steel including screws, nuts, bolts, washers, etc.;
B. Acceptable Hardware Manufacturers
   1. City Approved

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install supporting devices to fasten electrical components securely and permanently in accordance with NEC® requirements.
B. Coordinate with building structural system and with other electrical and mechanical installations.

3.2 CONDUIT SUPPORTS

A. Conform to Manufacturer's recommendations for selection and installation of supports.
B. Strength of each support shall be adequate to carry present and future load with a safety factor of at least four, or 200 pounds, whichever is greater.
C. Do not use perforated strap or plumbers tape for conduit supports.
D. RGS Conduit on Concrete or Masonry:
    1. Use one-hole malleable iron clamps with pipe spacers (clamp backs) or preformed Type 316 stainless steel channels.
    2. Anchor with metallic expansion anchors and screws or from preset inserts.
    3. Use present inserts in pre-stressed concrete.
    4. On plaster or stucco, use one-hole stainless steel straps with stainless steel toggle bolts.
E. Supports at Structural Steel Members: Use Type 316 stainless steel beam clamps.
F. Wherever conduit may be affected by dissimilar movements of the supporting structures or medium, provide flexible or expansion devices.

3.3 ADJUSTING AND CLEANING

A. The devices described in this section shall be adjusted accordingly per Manufacturer’s recommendations.
B. Clean exposed surfaces using Manufacturer recommended materials and methods.

3.4 TESTING

A. Perform installation tests in accordance with applicable NEC®, NEMA and UL requirements.

3.5 STARTUP SERVICES

A. Verify that all devices are installed and connected according to the Contract Documents.
B. Verify that installation complies with requirements in Division 16 Sections.
C. Complete installation and startup checks according to Manufacturer's written instructions.

3.6 WARRANTY

A. Equipment Manufacturer warrants that all goods supplied are free of non-conformities in workmanship and materials for one year from date of Substantial Completion.

End of Section

Section 16265

UNINTERRUPTIBLE POWER SUPPLY

PART 1 - GENERAL

1.1 SCOPE

A. The CONTRACTOR shall furnish and install a three-phase continuous duty, on-line, double conversion, solid-state uninterruptible power system, hereafter referred to as the UPS with a minimum battery backup time of 30 minutes. The UPS shall operate in conjunction with the building electrical system to provide power conditioning, back-up and distribution for critical electrical process instrumentation loads as shown on the electrical drawings. The UPS shall consist of the UPS module, batteries or other DC storage systems, and accessory cabinets for maintenance bypass and distribution applications, and other features as described in this specification.

1.2 RELATED SECTIONS

1.3 SYSTEM DESCRIPTION

A. The UPS system will include a minimum of (1) rectifier, (1) inverter, (1) static bypass, (1) maintenance bypass, (1) battery system and associated control and monitoring panel.

B. Components:
   1. Rectifier
   2. Inverter
   3. Sealed Lead Acid Batteries
   4. Battery Charger
   5. Automatic Bypass
   6. User Interface Panel
   7. Serial (RS-232) Communication Interface
   8. Communication Card Slots (2)
   9. Relay Output Contact (2)
   10. Environmental Inputs (2)
   11. Hardwired Input, Output
   12. External Matching Battery Cabinets
   13. Maintenance Bypass Module
       a. MBP internal to UPS module
   14. SNMP/Web Adapter

C. Modes of Operation: The UPS shall operate as an online, double-conversion UPS with the following modes:
   1. Normal During the Normal or Double-conversion Mode the rectifier shall derive power as needed from the commercial AC utility or generator source and supply filtered and regulated DC power to the online inverter. The inverter shall convert the DC power to highly regulated and filtered AC power for the critical loads.

2. Battery Upon failure of the AC input source, the critical load must continue to be supplied by the inverter without switching. The inverter must obtain its power from the battery. There must be no interruption in power to the critical load upon failure or restoration of the AC input source.
3. Recharge Upon restoration of the AC input source, the rectifier/battery charger must recharge the battery. The inverter shall, without interruption of power, regulate the power to the critical load.
4. Bypass: The static bypass switch must be used for transferring the critical load to the AC utility supply without interruption. Automatic re-transfer to normal operation must also be accomplished without interruption of power to the critical load. The static bypass switch must be capable of manual operation.
5. Integral Maintenance Bypass: The maintenance bypass is used for supplying the load directly from the AC utility supply, while the UPS is isolated for maintenance or repair.

D. The UPS and all components shall be designed, manufactured and tested in accordance with the latest applicable standards of NEMA and UL as follows. Where a conflict arises between these documents and statements made herein, the statements in this specification shall govern.
   1. Safety
      a. IEC 62040-1-1 or EN 62040-1-1
      b. EN 60950
      c. UL 1778
   2. Emission and Immunity:
      a. EN 50091-2 (Emissions Class A and Harmonics)
      b. EN61000-4-2,-3,-4,-5 - Slow high energy surges in input/output lines: 1 kV. line/earth, 0.5 kV line/line (IEC 61000-4-5) - Fast low energy transients in power lines: 2 kV. line/earth (IEC 61000-4-4) - Fast low energy transients (burst) in control and signal lines: 1 kV line/earth (IEC 61000-4-4) - Electrostatic discharge (ESD): 8 kV air discharge, 6 kV contact discharge (IEC 61000-4-2) - Electromagnetic field: IEC 61000-4-3 level 3
      c. FCC Class A15J

E. Markings
   1. UL and NOM

1.4 SUBMITTALS – FOR REVIEW/APPROVAL

A. Submit one copy of a concise operation and maintenance manual.

1.5 SUBMITTALS – FOR CONSTRUCTION

A. Submit one copy of a concise operation and maintenance manual.

1.6 QUALIFICATIONS

A. The manufacturer of the unit shall have a minimum of forty years experience in the design, manufacture, and testing of Uninterruptible Power Supplies.

B. For the equipment specified herein, the manufacturer shall be ISO 9001.
C. Provide Seismic tested equipment as follows:
1. The equipment and major components shall be suitable for and certified to meet all applicable seismic requirements of the California Building Code (CBC) through zone 4 application.

1.7 REGULATORY REQUIREMENTS
A. The UPS shall be UL labeled.

1.8 DELIVERY, STORAGE AND HANDLING
A. Equipment shall be handled and stored in accordance with manufacturer's instructions. One (1) copy of these instructions shall be included with the equipment at time of shipment.

1.9 OPERATION AND MAINTENANCE MANUALS
A. Equipment operation and maintenance manuals shall be provided with each assembly shipped and shall include instruction leaflets, instruction bulletins and renewal parts lists where applicable, for the complete assembly and each major component, products.

1.10 MANUFACTURERS
A. Eaton /Powerware, Schneider Electric – APC or approved equal.

1.11 RATINGS
A. System Input
1. Input Voltage Operation Range
a. Nominal 120/208 VAC, 4-wire plus ground
b. +10% to –15% from nominal
2. Input Frequency
a. 45 to 65 Hz
b. auto-sensing
c. capable of 50 to 60 Hz or 60 to 50 Hz frequency conversion
3. Input Power Factor: 0.99 typical
4. Input Current Distortion: 5% THD maximum at full rated linear load
5. Inrush Current:
a. <2x branch rating without input transformer
b. <5x branch rating with input transformer
6. Surge Protection:
a. Line to Line 180J
b. Line to Ground 450J
B. System Output, Normal Mode -Nominal Output Voltage 208/120 VAC, Selectable through front panel or through serial port connection with power management software.
1. Voltage regulation: +/-2% of selected output voltage in steady state
2. Transient Voltage Response: Meets Class 1 performance of IEC62040-3
3. Voltage THD:

a. 2% Total Harmonic Distortion (THD) maximum phase to neutral into a maximum rated linear load (5% phase to phase)
b. 5% THD maximum phase to neutral into a maximum rated non-linear load (7% phase to phase)

4. Nominal Frequency: 50 or 60 Hz selectable
5. Frequency Regulation:
   a. 50/60 Hz +/- 0.5 to +/- 3.0 Hz selectable, synchronized to mains, +/- 0.005 Hz free running single units
   b. +/- 0.15 Hz parallel units
6. Slew rate:
   a. selectable to 1.0, 2.0, 3.0 Hz/s for single units,
   b. < 0.5 Hz/s for parallel units;
   c. Generator Mode (6 / 7.5 Hz/s) for single units selectable through software parameters that can be configured via LCD and service PC interface
7. Output Current: Maximum output current (at nominal output voltage) for the UPS shall be:
   a. 15 kVA system: 41.6 A @ 208 V
8. Current Overload Capability without Bypass:
   a. 125% for 1 min
   b. 150% for 5 seconds
   c. >150% for 300 ms
9. Bypass:
   a. Automatic bypass shall provide an alternate path to power in the case of overload, inverter failure or other UPS failure
   b. Internal Maintenance Bypass can be utilized with the UPS to allow servicing of the UPS
   c. Transfer time to and from any internal bypass shall be no-break
10. Efficiency: Typical >91% while in normal mode, with nominal line conditions

C. System Output, Battery Mode
1. Nominal Output Voltage: This shall be the user-selected output voltage
2. Voltage Regulation: +/-1% phase to neutral of selected nominal voltage (+/-2% phase to phase)
3. Transient Voltage Response
   a. Meets Class 1 performance of IEC62040-3
   b. +/-5% for 100% step load change; recovery in <1ms
4. Voltage THD:
   a. 2% Total Harmonic Distortion (THD) maximum into a maximum rated linear load
   b. 5% THD maximum phase to neutral into a maximum rated non-linear load (7% phase to phase)
5. Frequency Regulation: +/-0.005 Hz of selected nominal frequency
6. Overload Capacity:
   a. 125% for 1 min
   b. 150% for 5 seconds
   c. >150% for 300 ms

1.12 CONSTRUCTION

A. The UPS system shall be provided as a single-module, non-redundant system. The UPS shall be field-upgradeable for power rating 15 kVA, additional parallel capacity or for redundant operation. The system shall be configured with the following options:
   1. External Matching Battery Cabinets
   2. Several Connectivity Options
   3. Internal Maintenance Bypass Switch

B. Converter (rectifier): Incoming power shall be filtered and converted to DC by a sine-wave rectifier. The rectifier corrects the input power factor to 0.99 and draws sinusoidal current (with less than 5% THD) from the utility. In the event of utility failure, the DC-DC converter shall be supplied power without interruption from the internal or external batteries.
   1. Overload Capacity: The converter shall be capable of supplying up to 150% of rated load for at least five (5) seconds if no bypass is available.

C. Inverter: The inverter converts the DC power from the rectifier or converter to regulated AC power for output to critical loads.
   1. Output Voltage: The inverter output voltage is specified in section 1.12.B.
   2. Voltage Regulation: The inverter steady state voltage regulation is +/- 1% phase to neutral, 2% phase to phase. Dynamic regulation meets Class 1 performance of IEC62040-3.
   3. Frequency Control: The inverter steady state frequency regulation is +/-0.005 Hz, free running in steady state. UPS is synchronized to Utility in normal operation.

D. Mechanical Construction
   1. All materials and components of the UPS shall be new, of current manufacture, and shall not have been in prior service except as required during factory testing. The UPS shall be constructed of replaceable subassemblies. All active electronic devices shall be solid-state.
   2. The UPS unit is comprised of an input rectifier, battery charger, inverter, bypass, and battery consisting of the appropriate number of sealed battery modules, and shall be housed in a single freestanding enclosure. The UPS cabinet shall be cleaned, primed, and painted with the manufacturer's standard color. Casters and leveling feet shall be provided as standard.
   3. Matching external battery cabinets shall be available in different sizes.
   4. Dimensions of standard UPS and external battery or option cabinets:

Enclosure	Dimensions (H x W x D)	Weight (inc. bat)
UPS:	66 x 20 x 34 inches	1105 lbs
½ BATTERY CAB:	66 x 20 x 31 inches	1100 lbs
FULL BATT CAB:	66 x 20 x 31 inches	2060lbs

OPTION CAB MBP ONLY:	66 x 20 x 34 inches	205 lbs
OPT CAB W/TRANSFORMER:	66 x 20 x 34 inches	535 lbs

1.13 SYSTEM INPUT & OUTPUT CONNECTIONS

A. AC Input:
   1. All UPS units shall be capable of utilizing hardwired input. Option cabinets will contain sufficient power cabling to connect to the UPS power terminals when the Option cabinets are placed adjacent to the UPS.
   2. Input neutral is required for proper UPS operation unless input transformer option is used.
B. AC Output:
C. All UPS units shall be capable of utilizing hardwired output
D. Extended Battery Connector: External battery cabinets include cable to connect each battery cabinet to the UPS or daisy chain external battery cabinets.
E. Serial (RS-232) Communication Interface: A 9-pin sub-D connector shall provide capability for communicating with manufacture-supplied software package. The UPS shall also provide signals for indication of UPS alarm status.
F. (2) Communication Card Slots: The UPS shall provide (2) communication X-slots in the back of the UPS allowing for additional connectivity options, including SNMP/Web, AS/400 relays, Modbus/Jbus capabilities, etc.
G. (2) Programmable Input Connections: The UPS shall provide built-in inputs for field connection (environmental input). The inputs shall be parameter programmable to suit the needs of the application.

1.14 USER INTERFACE

A. Front Panel Display: The UPS shall include a front panel display consisting of a graphical LCD display with backlight, four status LED's, and a four-key keypad.
   1. Graphical LCD display: Includes basic language (English and local selectable language), display of unit function and operating parameters. It shall be used to signify the operating state of the UPS, for indicating alarms, for changing operations control parameters and set points.
   2. Four status LED's, which indicate:
      a. Alarms, with a red LED
      b. On Battery, with a yellow LED
      c. On Bypass, with a yellow LED
      d. Power On, with a green LED
   3. Four-Key Multifunction Keypad: UPS shall have keypad to allow user to adjust UPS parameters, view alarm and inverter logs, change UPS operational modes, and turn the UPS on and off.

B. Power Management Software Package: The UPS shall include serial communications interface that provides the following communication capabilities:
   1. Monitor and graphically display input and output voltage and other operating characteristics
   2. Notify end-users in the event of a power anomaly via network, E-mail or page.
   3. Communication Ports:
      a. Communication Card Slots: The UPS shall provide (2) communication X-slots in the back of the UPS allowing for additional connectivity options, including SNMP/Web, AS/400 relays, Modbus/Jbus capabilities, etc.
      b. Serial communications (via RS-232) with manufacturer-supplied power management software package

1.15 BATTERIES

A. Battery Type: Valve Regulated Lead Acid (VRLA), minimum two-year warranted float service life at 25 degrees C
B. UPS Holdover Time (Runtime): Each UPS system, consisting of a minimum of six battery strings (108 battery blocks) for each power module shall have a minimum holdover time of 11 minutes, depending on kVA rating.
C. Extended Holdover Time (Runtime): Each UPS system shall have capability for addition of extra matching battery cabinets (in two cabinet configurations) to increase the total holdover time. Please refer to datasheet for a list of runtimes. The battery times listed are approximate and may vary depending on load configuration, temperature, battery age, and battery charge.
D. Battery Recharge Time:
   1. Base UPS system consisting of six (6) battery strings will have a recharge time of max. 1.75 hours to 95% usable capacity @ nominal line after a full load discharge (30 kVA).
E. Bus Voltage: Nominal bus voltage is 216 VDC. Each string consists of 18 battery blocks in series with 9 Ah capacity.
F. Battery Protection:
   1. Short Circuit Protection: Over-current protection shall protect the batteries from all short circuit fault conditions
   2. Battery Module Protection: Internal battery circuit breaker shall be provided
   3. Under-voltage Protection:
      a. Inverter cutoff voltage: Battery operation shall be terminated when the battery voltage drops to the 1.67 VPC set point
   4. Protective shutdown voltage: Inverter shall shutdown after 1 minute when the battery voltage drops below 1.7 VPC volts-per-cell typical
   5. Over-voltage Protection: If the UPS system's battery bus voltage exceeds the predetermined set point then the UPS will disable the charger and alarm a high battery condition
G. Advanced Battery Management:

1. Battery recharge: After recharging batteries to full capacity, the charger will enter the rest mode to increase the battery lifetime according the ABM cycle. Hence, continuous float charging of the battery shall not be allowed. The active battery charger states are constant-current (charge mode), constant-voltage (float mode) and no-charge (rest mode).
2. Battery Runtime Monitoring: UPS shall monitor batteries and provide status to end user of battery runtime via front panel, serial communications, or both. Runtime calculations to be based on load demand and analysis of battery health.
3. Battery Health Monitoring: UPS shall periodically test and monitor battery health and provide warnings visually, audibly and/or serially when battery capacity falls below 80% of original capacity. Battery testing may also be user initiated via front panel or serial communications.

1.16 NAMEPLATES

A. Provide a printed nameplate for the UPS.

1.17 ENVIRONMENTAL CONDITIONS

A. The UPS shall be certified to the following safety standards:
   1. EN 62040-1-1, IEC 62040-1-1, EN 60950
B. The UPS shall meet CISPR22 Class A (EN50091-2) for Emissions and EN50091-2 (IEC6100032 for 16 amps or less) for Harmonics
C. Audible Noise: Less than 57 dBA (A weighted) at one (1) meter from all sides in all system modes
D. Ambient Temperature
   1. Operating: UPS 0 deg C to +40 deg C
   2. Storage: UPS 0 deg C to +25 deg C
E. Relative Humidity
   1. Operating: 5 to 95% non-condensing.
   2. Storage: 5 to 95% non-condensing.
F. Altitude
   1. Operating: To 3000 meters--de-rating or reducing operating temperature range may be required for higher altitudes
   2. Transit: To 10,000 meters
G. Electrostatic Discharge: The UPS shall be able to withstand a minimum 8 kV without damage and without affecting the critical load

PART 2 - EXECUTION

2.1 FACTORY TESTING

A. The following standard factory tests shall be performed on the equipment provided under this section. All tests shall be in accordance with the latest version of NEMA and UL standards.
   1. Standard Computer-automated UPS system test
   2. Hipot test

2.2 INSTALLATION

A. The Contractors shall install all equipment per the manufacturer's recommendations.

2.3 FIELD QUALITY CONTROL

A. Provide the services of a qualified factory-trained manufacturer's representative to assist the Contractor in installation and start-up of the equipment specified under this section for a period of 2 working days. The manufacturer's representative shall provide technical direction and assistance to the Contractor in general assembly of the equipment, connections and adjustments, and testing of the assembly and components contained therein.
B. The Contractor shall provide three (3) copies of the manufacturer's field start-up report.

2.4 WARRANTY

A. All components of the UPS system shall be covered by a standard one-year limited factory warranty and service protection package.
B. One-year limited factory warranty shall include replacement coverage for the UPS parts for a period of 18 months from shipment or 12 months from start-up, whichever occurs sooner. Labor coverage is for 90 days after product startup.
C. One-year service protection package shall include 7x24 on-site repair/replacement labor for UPS parts and batteries; 7x24 technical support coverage; and 7x24 remote monitoring service (with monthly reports for UPS and battery performance). Standard response time shall be 8 hours from receipt of call. Manufacturer shall also offer, as an option, 7x24 on-site service support with guaranteed response times of 4, or 2 hours in certain major metropolitan areas. Additional preventive maintenance visits shall be available as an option for both UPS and battery components.
D. Manufacturer shall also include Start-up services consisting of: 7x 24 Start-up service of UPS and batteries. On-site user training, Site Audit, installation and commissioning of monitoring service, and validation of one-year limited factory warranty will be performed during the start-up.
E. Manufacturer shall also offer an optional service plan to provide 7x24 on-site coverage (preventive and corrective) for UPS and batteries, guaranteed response time, remote monitoring, Web access to service site history, annual Site Audit, UPS and battery preventive maintenance visit, and discounts on upgrade and modification kits. Manufacturer shall also provide a battery service plan to provide parts-and-labor coverage for partial and full battery strings, either with preventive maintenance or replacement coverage.

END OF SECTION

SECTION 16325

480-VOLT SWITCHGEAR

PART 1 - GENERAL

1.1. SCOPE

A. Furnish and install the 480VAC rear-connected switchgear (no side access) with draw-out breakers as shown on the Contract Drawings and as specified herein. Breakers shall be electrically operated and interlocked for operation via local HMI and owner's existing remote SCADA system, selectable via a software switch on the Local HMI.

B. Related Work Specified Elsewhere
   1. Division 1 – General Requirements;
   2. Division 16 – Electrical;

1.2. REFERENCES

A. All characteristics, definitions, and terminology, except as specifically covered in this Specification, shall be in accordance with the latest revision of the following standards:
   1. ANSI/IEEE C37.13 - Low Voltage AC Power Circuit Breakers Used in Enclosures;
   2. ANSI C37.16 - Preferred Ratings, Related Requirements and Application for Low Voltage Power Circuit Breakers and AC Power Circuit Protectors;
   3. ANSI/IEEE C37.17 - Trip Devices for AC and General Purpose DC Low Voltage Power Circuit Breakers;
   4. ANSI/IEEE C37.20.1 – Metal-Enclosed Low Voltage Power Circuit Breaker Switchgear;
   5. ANSI/IEEE C37.50 – Test Procedure for Low Voltage AC Power Circuit Breakers Used in Enclosures;
   6. ANSI/IEEE C37.51 – Conformance Testing of Metal-Enclosed Low Voltage AC Power Circuit Breaker Switchgear Assemblies;
   7. American Society for Testing and Materials (ASTM) D-178 - Rubber Insulating Matting;
   8. National Electrical Contractors Association (NECA) National Electrical Installation Standards (NEIS);
   9. NECA 1 - Standard Practice of Good Workmanship in Electrical Construction;
   10. NEMA SG5 - Power Switchgear Assemblies;
   11. NEMA SG3 - Low Voltage Power Circuit Breakers;
   12. National Fire Protection Association (NFPA) 70 – National Electrical Code (NEC®);
   13. NFPA 70E® - Electrical Safety in the Workplace;
   14. UL 1558 - Metal-Enclosed Low Voltage Power Circuit Breaker Switchgear;

15. UL 1066 - Low Voltage AC and DC Power Circuit Breakers Used in Enclosures;

B. Solid-state circuitry shall meet or exceed the Transient Overvoltage Withstand Test per NEMA ISCI-109 and the Surge Withstand Capability Tests (SWC) per IEEE Standard 472 (ANSI C37. 90A). In addition, where UL Standards exist for components, devices and/or assemblies, such standards shall apply.

C. Where reference is made to one of the above standards, the revision In effect at the time of bid opening shall apply.

1.3. SUBMITTALS

A. Submit shop drawings in accordance with the General Conditions and Section 01300.

B. All submittal documents shall be provided in both hardcopy, bounded in separate three-ring binders, indexed, tabbed with sectional dividers, and no larger than 8½-inch x 11-inch and bookmarked electronic media - Adobe® Acrobat® portable document format. Two sets of hardcopy and two sets of electronic media shall be provided.

C. All drawings shall be provided in both hardcopy, bounded, indexed, and no larger than 11-inch x 17-inch and bookmarked electronic media - Autodesk® AutoCAD® file format AND Adobe® Acrobat® portable document format. Two sets of hardcopy and two sets of electronic media shall be provided. D. Submit shop drawings and product data for the following:

1. Equipment shop drawings showing elevation and plan views, conduit entrance spaces, nameplate data, bus arrangement, dimensions, and weight, shipping splits and metering layouts. Indicate all options, special features, ratings and deviations from this Section.
2. Point-to-point compartment wiring diagrams for metering, relay, and control circuits. Show wire and terminal numbers. This diagram shall include all interfaces to other control panels.
3. Product data sheets and catalog numbers for circuit breakers, trip devices and protective relays. List all options, trip adjustments and accessories furnished specifically for this project.
4. Itemized bill of materials for metering, protective relays, accessories and control equipment.
5. Instruction and maintenance manuals for switchgear, breakers and all third party components such as relays, switches and meters, etc.,
6. Itemized list of spare parts furnished specifically for this project, including quantities, description and part numbers.
7. Certified shop test reports for breakers and switchgear
8. Installing contractor shall furnish field test and inspection reports.

1.4. QUALITY ASSURANCE

A. The Low-Voltage Switchgear MANUFACTURER shall have a minimum of ten (10) years consecutive experience producing similar electrical equipment.

B. The Low-Voltage Switchgear MANUFACTURER shall be ISO certified.
C. UL Listing Requirements –
   1. "Manufactured in accordance with" is not equivalent to "UL LISTED" and does not meet the intent of this specification;
   2. The Low-Voltage Switchgear shall be posted at www.UL.com under Category Code "FHCW"; Products without posting at UL.com shall not be approved. To access UL Category Code, click on Certifications of UL's home page. Type "FHCW" into the Category Code search box and click Search;
D. The MANUFACTURER of the switchgear assembly shall be the same MANUFACTURER as the breakers.
E. All sections and devices shall be UL Listed and labeled.
F. Service equipment shall be UL labeled as suitable for use as service entrance equipment.

1.5. DELIVERY, STORAGE AND HANDLING

A. Deliver products and equipment in factory labeled packages that include recommended storage practices placed on the outside of the shipping container. Shipping groups shall not exceed 15-feet in length.
B. Circuit breakers shall be shipped inside their respective cells in which they were factory acceptance tested.
C. Store and handle in strict compliance with MANUFACTURER's instructions and recommendations. Protect from potential damage from weather and construction operations. Store so condensation will not form on or in switchgear and if necessary, apply temporary heat where required to obtain suitable service conditions.

1.6. MAINTENANCE

A. Furnish the following maintenance accessories, operating and maintenance manuals for the switchgear.
   1. Breaker remote racking device with rail provisions installed on each draw out breaker cubicle for safe installation and removal of circuit breaker with a remote 30-foot corded operator.
   2. Circuit-Breaker Portable Test Set: For testing all functions of circuit breaker, solid-state trip devices without removal from switchgear;
   3. Circuit-Breaker Removal Apparatus: Overhead-circuit-breaker lifting device, track mounted at top front of switchgear, complete with hoist and lifting yokes;
B. Provide the following spare parts in the quantities specified:
   1. Six (6) of each type and rating of fuse used. Include spares for potential transformer fuses and control power fuses;
   2. Two (2) half pint containers of paint matching enclosure finish;
   3. Qty One (1) of each type frame breaker supplied ready to replace an installed breaker complete with trip unit
   4. Provide spare PLC's, I/O Modules, Ethernet Switches, Touch panels, and Communication Gateways at a rate of 10% of total (1 spare for every 10 provided).

5. Provide Qty One (1) each of the following per Switchgear Lineup:
a. Trip Unit
b. Rating Plug – 1 for each different size breaker, per switchgear lineup
c. Auxiliary Contacts
d. UVR – Per lineup, if lineup is designed to include UVR's
e. Close coil
f. Open coil
g. Charging Motor
h. Breaker Communication Module
i. 1 set of Secondary Block Contacts
6. Spare parts shall be boxed or packaged for long-term storage and clearly identified on the exterior of the package. Identify each item with MANUFACTURERs name, description and part number.

PART 2 – PRODUCTS

2.1 RATINGS

A. Service: 480VAC, 60 Hertz, 3-Phase, 3 or 4 Wire, solidly grounded system, as per location.

B. The switchgear and protective devices shall have a fully rated, short circuit withstand rating as required by the contract documents.

C. The continuous current rating of the bus shall be as noted in the contract documents. The bus shall be designed to carry its rated continuous current in the specified ambient temperature without exceeding the equipment temperature rise limits. Bus bracing shall exceed the specified equipment short circuit rating.

1. Line and load bus connections to feeder devices shall be rated to carry the full continuous current of the device frame.

2.2 CONSTRUCTION

A. General:

1. The switchgear shall be factory assembled and tested and comply with applicable industry standards. It shall be a coordinated design so that shipping groups are easily connected together at the site into a continuous line-up. Necessary connecting materials shall be furnished. All power circuit breakers and assemblies shall be produced by a single
2. MANUFACTURER.
3. The switchgear assembly shall consist of one or more metal-enclosed sections in an indoor NEMA 1 gasketed enclosure.
   a. End sections shall include provisions for main bus extension and installation of future vertical sections.
   b. The design shall incorporate preformed steel channels, angles and structural components bolted together and reinforced to form a rigid, self-supporting assembly.

c. Fabricate enclosure with removable, hinged rear doors with captive screws to allow access to rear interior of switchgear.

4. Front breaker doors and covers must be free of any ventilation openings regardless of breaker size.
5. Circuit breaker compartments shall include stationary primary contact disconnects that shall be silver-plated copper at the connection points and of one-piece construction.
   a. The upper set of disconnects shall bolt directly to the main bus and, for feeder circuit breakers, the lower set shall extend to the rear cable area and shall be insulated where they pass through the main bus compartment.
   b. Primary disconnects shall be sized for the maximum continuous current for the frame size of the circuit breaker which is located in the compartment.
   c. Interlocks shall be provided to prevent a circuit breaker element of the incorrect frame size or interrupting rating from being inserted into the compartment.
   d. Secondary control and communication connections shall be located in a separately accessed area that is accessible from the front of the switchgear without exposing any power cables or bussing. The secondary control contacts shall be of the sliding contact design, silver plated and engage when the draw-out circuit breaker element is in either the “connected” or “test” positions.
6. All control wiring within the assembly shall be continuous and shall terminate on each end at a suitable terminal block. No splices shall be allowed. Control wiring shall be 14 AWG minimum, stranded type SIS and shall be labeled at each end with sleeve-type wire markers.
   a. Wire markers shall be machine imprinted with the wire name as indicated on the wiring diagrams.
   b. Terminals shall be insulated locking fork or ring tongue type except where connecting to components that do not accept these terminations. Control wiring for external connections shall be terminated in a separate front accessible compartment for ease of access.
7. Bus isolation barriers shall be arranged to isolate the buses on either side of each main and tie circuit breaker from each other.
8. Main bus shall connect vertical sections and shall be uniform capacity the entire length of assembly. Vertical and horizontal bus bar shall utilize a channel shape design to maximize short circuit withstand capability and minimize heat rise. The main horizontal bus shall be run in a vertical, edge-to-edge arrangement for high short circuit strength. Access to the rear cable termination area shall be possible without reaching over the main and vertical bus.
   a. Bus shall be 98 % minimum conductivity copper tin-plated over entire length of the bus bar.

b. Feeder Circuit-Breaker Load Terminals: Plated copper bus extensions equipped with pressure connectors for outgoing circuit conductors.
c. Ground Bus shall be copper of 98 % minimum conductivity, minimum size 1/4 by 3-inches.
d. Bus bracing shall be equal to the short circuit interrupting rating of the lowest rated circuit breaker applied in the assembly or 100kA minimum.
e. Provide for future extensions from either end of main phase and ground bus by means of predrilled bolt holes and connecting links.

9. All spaces shown on the Contract Drawings shall be completely equipped to receive a future breaker
10. The switchgear shall be capable of being integrated with the plant's upper level SCADA system via Ethernet communications.
11. IP Addresses, Usernames and passwords, etc. to be provided by OWNER.
12. The Local Switchgear Control System shall be controlled with a Siemens PLC (S7-1500, Profinet) and Ignition HMI Web Based Platform (check with Owner for current version prior to purchase)
13. PLC Programming to be written in ladder logic, commented, and turned over to owner at the end of the project. Must use “best programming practices” using DB’s, Functions, etc. City to review final PLC code. Must provide a datamap to OWNER for upper level Scada system integration.
14. All Switchgears (double ended) shall have open transition main-tie-main transfer scheme using PLC and remote HMI Industrial 22” Touch screen PC. A 22” Touchscreen PC shall be installed on NEMA-1 Hoffman Box complete with connections to PLC. Industrial Touch screen PC HMI shall communicate with the pre-programmed PLC and act as the local master. Using the HMI of the local Industrial Touch screen PC, the user must be able to navigate back and forth between the elevation and one-line views of the LVS lineup. Utilizing the elevation or one-line screens, the user must be able to select (touch) an embedded intelligent device (breaker trip units, relay, SPD, etc.) and drill down to access screens that support monitoring and configuring of the breakers and intelligent devices. Additionally, user must able to switch automatic transfer scheme to LOCAL or REMOTE mode. A soft LOCAL /REMOTE switch on the main screen (elevation or single line view screen) shall be provided so operator can disable all remote operation, if work is being performed locally. Interlock to disable Remote Operation shall be provided if operator is standing on a Sensor Matt located on front of the switchgear. Interlock for this control will come from the Sensor Matt as a Digital Input to the PLC. Appropriate timers and delays shall be set from factory and functionality of the scheme shall be demonstrated during testing. HMI shall allow changing of pick-up settings, timings, and Open Transition

setpoints easily without any extensive programming. HMI should allow operator to change/configure breaker protective settings, change breaker settings into maintenance mode, and shall provide trending reports, power metering and trip logs. Additionally, all as-built drawings, maintenance manuals and other relevant documentation shall be available in PDF format at the HMI.

15. Industrial quality PLC shall be Siemens. It shall be installed inside control cubicle of switchgear in a 42" wide two high section as shown on plans and elevations. This compartment shall include all I/O, industrial PLC, UPS, and other control components as required to comply with requirements of the switchgear spec. Communication cables to remote HMI shall be extended in conduit per plans. Communication cables between switchgear and HMI shall be furnished and terminated by switchgear manufacturer. He shall also program the HMI from the factory and adjust in the field as required. HMI and PLC shall be connected to existing ethernet communication cabinet for interfacing with SCADA system.
16. Switchgear manufacturer shall coordinate with the UPS being provided in Section 16265. Manufacturer shall provide sizing calculations in the switchgear shop drawing submittals to confirm proper UPS sizing.
17. Local HMI shall include, but not be limited to, the following functionality, displayed information, or trended data:
    a. OUTPUT **COMMANDS**
        1) Close Command
        2) Open Command
        3) Reset Command
        4) Software switches on local HMI to switch between LOCAL HMI control and Upper Level SCADA Control.
    b. BINARY **STATUS**
        1) Fail to Close
        2) Fail to Open
        3) External Trip (if applicable)
        4) Position Test
        5) Position Disconnect
        6) Position Not Available
        7) Over current – Long Time
        8) Over current – Short Time
        9) Over current - Instantaneous
        10) Over current - Neutral
        11) Over current - Ground
        12) Over current – Extended Trip
        13) Not Write Enabled
        14) Communication Failure
        15) Not Ready to Close
        16) Long Time Pickup Present
        17) General Alarm Present
        18) Trip Coil Monitor Alarm(if applicable)

19) Under Voltage Release Alarm(if applicable)
20) Spring Not Charged
21) Event – Closed
22) Event – Connect
23) Event – No Current Trip
24) Event – Ready To Close
25) Breaker in Alarm (Tripped)

c. VALUES
1) Source Under Voltage
2) Source Overvoltage
3) Source Under Frequency
4) Source Over Frequency
5) Source Voltage Unbalance
6) Source Dead Bus
7) % Phase Unbalance Current
8) Current L1
9) Current L2
10) Current L3
11) Mean Current Average (I average)
12) Current Neutral Conductor
13) Current in Ground
14) % Phase Unbalance Voltage
15) L1-L2 Voltage
16) L2-L3 Voltage
17) L3-L1 Voltage
18) L1 Voltage
19) L2 Voltage
20) L3 Voltage
21) Mean Value L-L Voltage
22) Mean Value L-N Voltage
23) Total Apparent Power
24) Total Active Power (Real 3 Phase)
25) Total Reactive Power
26) Active Energy Normal Direction
27) Active Energy Reverse Direction
28) Reactive Energy Normal Direction
29) Reactive Energy Reverse Direction
30) Total Power Factor
31) Frequency
32) Active Power Normal Direction kWh
33) Active Power Reverse Direction kWh
34) Reactive Power Normal Direction kWh
35) Reactive Power Reverse Direction kWh

18. Local HMI shall be an Industrial Touch screen PC. No thin clients will be accepted. The local Industrial Touch screen PC shall have a local installation of Inductive Automation's Ignition Product. HMI Screens shall be submitted and approved by OWNER prior to implementation.

19. Specs for hardware and software are as follows:
    a. Industrial PC
        1) SIMATIC IPC Panel PC or City of Orlando's approved equal
        2) 10/100/1000 MBIT/S Ethernet Ports (1 minimum)
        3) USB V3.0 (2 minimum),
        4) Front USB port (optional)
        5) 22" Touch screen, Resolution 1920 X 1080
        6) Core I5 Intel Processor or better
        7) Solid State Drive 100 GB minimum
        8) 16 GB RAM minimum
        9) Windows 11 Professional 64-Bit
    b. HMI Software
        1) Contractor to check with Owner for current version prior to purchase
        2) Ignition Switchgear Project Package / 5 Clients
        3) Package Includes: Vision 5-Clients, OPC-UA,
        4) Siemens, Modbus, TCP/UDP drivers.
        5) Total Care
        6) Includes unlimited phone technical support, discounts on training and design consultation, and free upgrades to any modules purchased.
20. Specification Division 13 shall be referenced for all other Automation Hardware and Software.
21. At a minimum, Switchgear shall include an 8-port Industrial Ethernet Switch as listed in Specification Division 13 and as needed, a Gateway device that converts the native protocol of the Switchgear to PROFINET® for communication with the Siemens PLC. The gateway and any other ancillary devices required for communication must be supplied by the same voltage source feeding the Ethernet switch in the switchgear.
22. Switchgear manufacturer's control systems programmer shall provide 40 hours of coordination efforts to assist the OWNER with integration of the Switchgear with the OWNERS upper level SCADA System.
23. The control power distribution shall be connected using transfer relays. Even if one of the power sources fails, these relays will provide the power from either source feeding the switchgear to the power supplies, only the removal of both sources will de-energize power supplies in the switchgear. Control power will be supplied by the UPS, as specified in Section 16265 to supply power to HMI, PLC and all breaker controls/operations. UPS shall be provided for external installation by the contractor. UPS trouble alarm shall be provided on HMI and on Owner's SCADA Control power distribution transfer scheme should be based on best available source.
24. Industrial Touch screen PC shall be remotely installed in wall mounted NEMA-1 enclosure, appropriate network switches and power supplies per the OWNER's System Standards Drawings and Division 13 specifications.

25. Source control required electrical interlocks with Mains and Tie breakers shall be provided to ensure that two sources are not paralleled. Interlocks shall be provided for manual operation (PLC not available) and submitted with shop drawings for review/approval.
26. Electrical interlocks shall also be provided between generator dock and main breakers with tie breaker in open/close positions.
27. Up to 5 Security/Password shall be available on HMI to ensure proper access to configuration and monitoring.

B. Structure:
1. The switchgear shall be a completely assembled unit of self-supporting construction, with voltage and current ratings as indicated on the Drawings. Each section of switchgear shall be a freestanding structure of bolted construction to rigidly support all devices and equipment. The sides shall be screw on code gauge steel plates, pan-type construction. The distribution protective devices shall be individually mounted with front-hinged cover plates and all necessary buses and straps shall be provided. Load terminals of feeder devices shall be extended to the front.
2. Protective devices shall be arranged so they are individually removable and readily interchangeable from the front of the switchgear. The breaker front shall be prominently labeled to indicate device ampere ratings and color coded for device type. ON-OFF indication and mechanism charged/ready status shall be clearly shown on breaker front window.
3. All bus bars shall be 98 percent conductivity copper. The bus structure shall be braced to withstand the stresses of a short circuit as required at the load terminals of the feeder device, and shall be mounted on supports of high impact non-tracking insulating material. Bus bars shall be uniformly arranged to provide A-B-C sequence left to right (from front), front to rear and top to bottom. Main buses shall be rated as indicated on the contract documents.
4. Insulated bus bar shall consist of bus bars enclosed in factory-applied, flame-retardant UL recognized insulation system. Bolted bus joints shall be insulated with secure joint covers that can easily be removed and reinstalled.
5. Bus/Cable compartment barriers: Barriers shall be supplied to isolate the rear cable area from the main bus area
6. A ground bus shall be provided running the full length of the switchgear, bolted to each vertical section.
7. Contractor shall solidly ground neutral from transformer. Neutral bus shall not be extended through full length of switchgear sections, with exception of switchgear for Area 8, which will be provided with neutral lugs only.
8. All hardware used on conductors shall be zinc or cadmium plated or approved equal, have a tensile strength of 120,000 psi.
9. The switchgear shall be provided in modular construction with adequate means for lifting, and shall be capable of being rolled or

moved into installation position and bolted directly to the floor without the use of floor sills.

10. All steel surfaces shall be chemically cleaned and treated to prevent moisture and rust under the paint film. The switchgear shall be painted with a heavy coat of ANSI No. 61 light gray enamel.

C. Circuit-Breakers and Trip Units

1. Circuit breakers shall comply with the requirements of IEEE/ANSI C37.13/16/17/50,UL1066, NEMA SG3. All breakers shall be three-pole, 100% rated type low voltage power breaker;
   a. Circuit breaker shall have connected, test and disconnected position indicators, spring charged/discharged indicators and circuit breaker open or closed and ready to close indicators all of which shall be visible to the operator with the compartment door closed. It shall be possible to rack the circuit breaker element from the connected to the disconnected position with the compartment door closed otherwise known as “through the door draw-out”;
   b. Provide interlocks to prevent racking the circuit breaker unless the breaker is open;
2. Ratings: Interrupting as required at 480VAC without fuses. Short time current ratings for each circuit breaker shall be as indicated on the Contract Drawings. Circuit breakers shall be 600VAC class.
3. Operating Mechanism: Mechanically and electrically trip-free, stored-energy operating mechanism with Normal Closing Speed: independent of both control and operator;
4. Each low voltage power circuit breaker shall be equipped with self-powered, microprocessor-based trip-device to sense overload and short circuit conditions. The device shall measure true RMS current. The tripping system shall consist of Rogowski coil sensors on each phase, a release mechanism and the following features:
   a. LCD Screen, field installable and interchangeable trip unit, which can be used with any, frame size circuit breaker. Trip units to include power metering modules and communication to Local HMI through the PLC.
   b. Functions: Long time, short time and extended instantaneous protection function shall be provided to allow the breaker to be applied at the withstand rating of the breaker with minus 0% tolerance so that there is no instantaneous override whatsoever. This feature shall furthermore allow the circuit breaker to be applied up to the full instantaneous rating of the breaker on systems where the available fault current exceeds the breakers withstand rating. Each shall have an adjustable pick-up setting. In addition, long time and short time bands shall each have adjustable time delay. Short time function shall include a switchable I2t ramp and optionally I4t to improve co-ordination with fuses or inverse relays.

c. Individual LED's shall indicate an over current, short circuit or ground fault trip condition. The data shall be maintained for a minimum of 48 hours without the need for a separate battery.
d. Pickup Points: 10 Long Time Settings.
e. Waveform capturing of 1s for both voltage and current shall be available locally at the trip unit display
f. Trip unit shall have a maintenance mode functionality which will allow lowering all settings (Long-Time, Short-Time, Instantaneous including delays) linearly. Capability to lower settings either locally at the trip unit or at remotely using SCADA or HMI. Blue light shall be provided on breaker compartment door to indicate maintenance mode activation.
g. All trip units shall have full metering capabilities and event shall have event logs, such as warnings, trip logs and maintenance detail. This information shall be available locally at the HMI or via communication to the Owner SCADA system.
h. Estimated contact wear shall be capable of being communicated remotely in addition to a local mechanical indication flag.
i. Future load changes shall be easily accommodated with change in the rating plug without change out of trip unit sensors.

5. Padlocking Provisions: For installing at least three (3) padlocks on each circuit breaker to prevent movement of the draw-out mechanism.
6. Modular communication and relaying accessories are to be available for retrofitting by the clients chosen Engineer. It shall not be necessary for the MANUFACTURERs personnel to retrofit accessories
7. The following items must be capable of being changed in the field: main contacts, CT's, trip units, racking mechanism and all internal & external accessories
8. Robust mechanism with shutters shall be provided in each breaker compartment, so upon withdrawal of circuit breaker from the compartment will cover all energized stabs in switchgear. (incoming and outgoing)
9. The following options shall be supplied for all breakers including feeders.
   a. Capable of being remotely electrically operated, open and closed via communication at the local HMI and/or SCADA
   b. Capable of being monitored for voltage, amperage, open/closed status via communication at the local HMI.
   c. Time-current characteristics shall be field adjustable locally or remotely via communication at the local HMI.

D. Miscellaneous Equipment
   1. Instrument Transformers: Comply with IEEE C57.13.
      a. Potential Transformers (PTs): Secondary-voltage rating of 120 V and NEMA accuracy class of 0.6 with burdens of W, X and Y.
      b. Current Transformers (CTs): Ratios as indicated; burden and accuracy class suitable for connected relays, meters, and instruments.

2. Provision for Future Devices: Equip future circuit-breaker compartments with rails, mounting brackets, supports, necessary appurtenances and bus connections;
3. Control Power Supply: Control power transformer supplying 120VAC control circuits through secondary disconnect devices are to be dry-type transformers with primary and secondary fuses. Equip with a best source control power system that will chose available control power source from any bus section (Main 1, Main 2, Generator Source Bus).
4. Provide IR Windows Qty-2 per feeder breaker section and Qty-1 for incoming mains.
5. Provide for bus joint temperature monitoring complete trending screen displaying temperature data and alarms available at the HMI or Owner's SCADA.
6. Provide cable connection monitoring complete with trending screen with temperature data and alarms available at the HMI or Owners' SCADA.
7. Provide maintenance switch on local and remote HMI screens to switch main and branch breakers trip settings to lower arc flash intensities in maintenance mode.

E. Surface Preparation and Shop Coatings
1. Steel parts shall be prepared for painting by a five-stage wash system consisting of an alkaline cleaner, fresh water rise, iron phosphate treatment, fresh water rise and non-chromate sealer. After cleaning and stabilization, the steel parts shall be coated with a thermosetting polyester powder applied with electrostatic equipment at a nominal 2 mils dry film thickness and then cured properly. The paint finish shall have a pencil hardness of 2H, a salt spray rating as defined in ASTM B-117-73 of 600 hours.
2. All non-current carrying metal parts of the switchgear assembly shall be cleaned of all weld spatters and other foreign material and given a hot iron-phosphate chemical treatment. A Zinc rich, heat cured, epoxy primer shall be applied to inhibit rust.
3. Indoor equipment shall be painted with one finish coat of manufacturer's standard air dried enamel. Color shall be light grey ANSI 61.
4. Unpainted non-current carrying parts shall receive protective zinc plating to prevent corrosion; the printed circuit boards shall be coated with a protective conformal epoxy coating. All device contacts shall be gold or silver plated.

2.3 FACTORY TESTING

A. Perform MANUFACTURER's standard production testing and inspection in accordance with ANSI standards. The MANUFACTURER shall submit certified copies of test results to indicate proof of compliance with ANSI C37.50 and C37.51 for review and approval before shipping.

B. Manufacturer shall create and provide an outline of testing procedures to the owner for review and approval. This same test procedure shall be used for OWNER witnessed testing in the field after installation.

2.4 ON SITE FACTORY TRAINING

A. Manufacturer to provide training to owner's personnel to demonstrate the complete functional capabilities of switchgear.
B. Manufacturer to provide a curriculum outline of the training and allocation training time required for review and approval to the ; "CA" Construction Administrator, before scheduling training
C. 40 hours of coordination efforts to assist the OWNER with integration of the Switchgear with the OWNERS upper level SCADA System must be completed and tested before onsite training can be submitted for scheduling. "Coordination efforts to assist the OWNER with upper level SCADA System" are not part of onsite factory training.
D. Owner will videotape all onsite training for future reference training.

2.5 ACCEPTABLE 480-VOLT SWITCHGEAR MANUFACTURERS

A. A. The listing of specific MANUFACTURERs does not imply acceptance of their products that do not meet the specified ratings, features and functions. MANUFACTURERs listed are not relieved from meeting these specifications in their entirety.
   1. EATON CORPORATION
   2. SIEMENS INDUSTRY

PART 3 – EXECUTION

3.1 INSTALLATION

A. The equipment shall be leveled and anchored directly to a concrete equipment pad or finished floor as shown on the Contract Drawings. Provide hardware and metal shims for installation. Grout and caulk all voids beneath the equipment base. Anchor bolts shall be 5/8-inch stainless steel, minimum sized and installed in accordance with the MANUFACTURER's recommendation.
B. Install the equipment in accordance with the MANUFACTURER’s instructions.
C. Remove temporary lifting angles, lugs, and shipping braces. Touch-up damaged paint finishes.

D. Make wiring interconnections between shipping splits.
E. Install bus splice plates and torque the connections.
F. Caulk seams, cracks, and openings in outdoor enclosures.
G. Successful vendor's equipment must fit in the space allocated as shown on electrical plans while providing NEC required clearance.

3.2 FIELD TESTING

A. Data Maps to be provided to OWNER to facilitate communication with upper level SCADA system. Data to be exchanged between the Switchgear PLC and the OWNER's upper level SCADA system shall be stored in data blocks.
B. A certified factory representative of the switchgear manufacturer shall inspect and test the installed equipment prior to energization. The switchgear manufacturer shall provide all material, labor, equipment and technical supervision to perform the tests and inspection. Testing shall cover all operating modes and interlocks.
C. Equipment testing and inspection shall be performed by an independent NETA certified testing company before energizing the switchgear in accordance with NETA Standard ATS and shall include the following:
    1. Visual and mechanical inspection;
    2. Ratio and polarity tests on current and voltage transformers;
    3. Ground resistance test;
    4. Insulation resistance tests (phase-to-phase and phase-to-ground);
    5. Meter calibration;
    6. Circuit breaker contact resistance test;
    7. Insulation power factor and resistance test for surge arresters;
    8. Phasing check;
    9. Primary current injection tests on each circuit;
C. In the event of an equipment fault, notify the ENGINEER immediately. After the cause of the fault has been identified and corrected, a joint inspection of the equipment shall be conducted by the CONTRACTOR, ENGINEER, OWNER and the equipment MANUFACTURER's factory service representative. Repair or replace the equipment as directed by the ENGINEER and OWNER prior to placing the equipment back into service.

3.3 ADJUSTMENT

A. The switchgear MANUFACTURER shall provide the services of a factory trained service representative(s) for at least 4 days. The first trip shall be coordinated with the field-testing. The second trip shall include any necessary follow-up or punch list work and technical instruction for the OWNER's designated personnel. The MANUFACTURER's service representative(s) shall demonstrate all operational features of the installed switchgear.
B. The switchgear MANUFACTURER's factory service representative(s) shall make the following tests and adjustments:
    1. Calibrate and test all circuit breaker trip devices, protective relays and controls per the final version of the breaker setting coordination study

and provide copy of those test results and settings in the owner's operation and maintenance manual for future use;

2. Adjust and lubricate circuit breaker operating mechanisms and contacts.

3.4 RUBBER MATS

A. Non-conductive switchboard matting is designed to provide insulation for the worker. Made from a PVC compound, the mat prevents the worker from being grounded, thereby eliminating the possibility of electrical shock. The corrugated saw-tooth top surface provides increased traction and is easy to sweep clean.

B. A three to four foot wide black rubber mat shall be furnished and installed on the floor and in front of each switchboard assembly. The mat shall be long enough to cover the full length of each line-up. The mat shall be ¼-inch thick with beveled edges, canvas back, and solid-type with corrugations running the entire length of the mat. The mat shall be guaranteed extra quality, free from cracks, blow holes or other defects detrimental to their mechanical or electrical strength. The mat shall meet OSHA requirements and the requirements of ANSI/ASTM D-178 for Type 2, Class 2 (30,000V) insulating matting.

C. A sensor mat FROM “Tape switch” shall be provided below insulating mat with sensor wiring, connected to switchgear smart breakers. This will prevent from smart breakers operating remotely thru SCADA system if someone is standing on this mat. A channel shall be installed to allow the wiring from the Tape Switch mat to pass through the concrete housekeeping pad directly into the appropriate switchgear compartment to avoid a tripping hazard caused by exposed conduit.

3.5 CLEANING

A. Remove all rubbish and debris from inside and around the switchgear. Remove dirt, dust, or concrete spatter from the interior and exterior of the equipment using brushes, vacuum cleaner, or clean, lint-free rags. Do not use compressed air.

3.6 WARRANTY

A. Equipment MANUFACTURER warrants that all goods supplied are free of nonconformities in workmanship and materials for one (1) year from date of Substantial Completion or 18 months from the shipment.

END OF SECTION

SECTION 16370

VARIABLE FREQUENCY DRIVES (VFD)

PART 1 - GENERAL

1.1 SCOPE

A. The Contractor shall furnish all labor, materials, equipment and incidentals required, to complete, ready for operation and delivery, the Variable Frequency Drive (VFD) depicted on the Contract Drawings.

B. Related Work Specified Elsewhere (if included):
   1. Division 1 – General Requirements;
   2. Division 2 – Site Work;
   3. Division 3 – Concrete;
   4. Division 11 – Equipment;
   5. Division 13 – Special Construction;
   6. Division 15 – Mechanical;
   7. Division 16 – Electrical;
      a. See Section 16921 - Low-Voltage (LV) Motor Control Centers (MCCs) for VFDs installed in MCCs;

C. Each VFD Control Panel shall be self-contained with all components correctly sized, based on the Owner's LIFT STATIONS STANDARDS;

D. Contractor shall follow the application specifics of the Owner's latest and applicable standards (attached) for VFD units;

E. Like items of equipment provided hereunder shall be the end product of one Manufacturer in order to achieve standardization for appearance, operation, maintenance, spare parts and Manufacturer's service.

F. Any modifications to a standard VFD product required to meet this specification shall be performed by the VFD Manufacturer only. Distributor or Systems Integrator hardware field changes to the VFD Manufacturer's product are specifically disallowed.

G. Furnish VFDs rated on basis of actual motor full load nameplate current rating and the Owner's VFD Standards HP Grouping of 1 to 20HP, 21 to 60HP, 61 to 100HP, 101 to 200HP or 201 to 400HP.

H. Input circuit breaker, interlocked with the enclosure door, with through-the-door handle to provide positive disconnect of incoming AC power and shall be capable of being locked in the open position.

I. All components listed shall be integral to the VFD lineup, factory wired and tested as a complete system.

J. If the Complete VFD Control Panel(s) is for one of the Owner's treatment facilities, the VFD assembly shall communicate with the plant SCADA System through PROFINET® or PROFIBUS® DP™ protocol. The communication device shall be manufactured and supported by the VFD Manufacturer. No third-party communication devices shall be used. VFD supplier shall coordinate with any others involved with the project (Electrical, Instrumentation, Integrator, etc.) for specific PROFINET® or PROFIBUS®

DP™ requirements of the VFD and provide all necessary items, connectors for a complete working system.

1.2 REFERENCES

A. All characteristics, definitions, and terminology, except as specifically covered in this Specification, shall be in accordance with the latest revision of the following standards:
   1. American National Standards Institute (ANSI) C62.41 - Guide for Surge Voltages in Low-Voltage AC Power Circuits;
   2. ANSI/ Institute of Electrical and Electronics Engineers (IEEE) 359-A-1-88 - Special Colors;
   3. IEEE 112 - Standard Test Procedure for Polyphase Induction Motors and Generators;
   4. IEEE 519 - Recommended Practices and Requirements for Harmonic Control in Electric Power Systems;
   5. National Electrical Manufacturer's Association (NEMA) CP 1 - Shunt Capacitors;
   6. NEMA MG 1 - Motors and Generators;
   7. NEMA 250 - Enclosures for Electrical Equipment (1,000 Volts Maximum);
   8. NEMA WC-57 - Control Cables;
   9. National Fire Protection Association® (NFPA®) 70 – National Electrical Code® (NEC®);
   10. NEC® Article 409 – Industrial Control Panels;
   11. NEC® Article 430 – Motors, Motor Circuits and Controllers;
   12. NFPA® 70E® - Electrical Safety in the Workplace;
   13. NFPA® 79 - Electrical Standard for Industrial Machinery;
   14. Underwriters Laboratories (UL) 508 - Industrial Control Equipment;
   15. UL 508A – Industrial Control Equipment;
   16. UL 508C - Power Conversion Equipment;

1.3 SUBMITTALS

A. Submit shop drawings in accordance with the General Conditions and Section 01420.
B. All submittal documents shall be provided in both hardcopy, bounded in separate three-ring binders, indexed, tabbed with sectional dividers, and no larger than 8½-inch x 11-inch and bookmarked electronic media - Adobe® Acrobat® portable document format. Two sets of hardcopies and two sets of electronic media shall be provided.
C. All drawings shall be provided in both hardcopy, bounded, indexed, and no larger than 11-inch x 17-inch and bookmarked electronic media - Autodesk® AutoCAD® file format AND Adobe® Acrobat® portable document format. Two sets of hardcopy and two sets of electronic media shall be provided.
D. The following information, at a minimum, shall be submitted to the Owner:
   1. Overall VFD operating data, including efficiencies, input currents, and power factors, at driven equipment actual load and rated system input voltage, at 0, 40, 60, 80, and 100 percent of rated speed;

2. Complete system ratings, including all nameplate data, continuous operation load capability throughout speed range of 0 to 100 percent of rated speed;
3. Complete VFD rating coordinated with motor full load nameplate current rating; list any controller special features being supplied;
4. VFD and reactor assembly dimensional drawings; information on size and location of space for incoming and outgoing conduit. Submit verification of overall dimensions;
5. Maximum heat dissipation from enclosure for all components furnished under this specification;
6. Submit layout of controller face showing pushbuttons, switches, instruments, indicating lights, operator interfaces, etc.;
7. Complete system operating description;
8. Complete system schematic (elementary) wiring diagrams;
9. Complete system interconnection diagrams between VFD, and isolation contactors, drive motor and all related components or controls external to system, including wire numbers and terminal board point identification;
10. One-line diagram of system, including component ratings;
11. Description of diagnostic features being provided;
12. Descriptive literature for all control devices such as relays, timers, etc.;
13. Itemized bill-of-materials listing all system components;
14. Submit list of recommended spare parts. Include at least one full set of fuses for each VFD;
15. Descriptive vendor literature submitted with bid documents will be accepted as reference only and will not be considered as specific submittal information and will not be evaluated for compliance with specifications;
16. A memory map, control and status words and configuration files and data for the Profibus DP Interface;
17. Complete dimensional layout of the VFD equipment room, to scale, demonstrating that proper clearances are met for all drive units to be installed as well as for future drive units;
18. Product data sheets for all components used;
19. Master drawing index;
20. Cable terminal sizes;
21. Component list;
22. Conduit space entry/exit locations;
23. Installation information;

E. The drives supplier to provide typical factory test description with the project bid; VFD Systems are to be 100% tested at the factory prior to shipment; Testing shall include motor load power;

F. VFD Systems commissioned in the field shall provide a complete startup report; The report shall include installation overview, application description, drive wiring, and parameter settings as configured for the application; Comments on drive performance as commissioned shall be noted in the field report; An electronic copy of the drive configuration shall be delivered to the Owner upon completion of the startup;

1.4 QUALITY ASSURANCE

A. The VFD Manufacturer of this equipment shall have a minimum of ten (10) years consecutive experience producing similar electrical equipment.
B. The VFD Manufacturer shall be ISO certified.
C. UL Listing Requirements –
   1. "Manufactured in accordance with" is not equivalent to "UL LISTED" and does not meet the intent of this specification;
   2. The VFD shall be posted at www.UL.com under Category Code "NMMS". Products without posting at UL.com shall not be approved. To access UL Category Code, click on Certifications of UL's home page. Type "NMMS" into the Category Code search box and click Search.

1.5 DELIVERY, STORAGE AND HANDLING

A. Deliver products and equipment in factory labeled packages that include recommended storage practices placed on the outside of the shipping container.
B. Handling and shipment of the products and equipment shall be in such a manner to prevent internal component damage, breakage, and denting and scoring of the enclosure finish.
C. Store and handle in strict compliance with Manufacturer's instructions and recommendations. Protect from potential damage from weather and construction operations. Store so condensation will not form on or in equipment and if necessary, apply temporary heat where required to obtain suitable service conditions.

1.6 SPARE PARTS

A. One (1) complete VFD Control Unit/Power Module, mounted in a reusable wooden shipping crate, of each size indicated on the Contract Drawings;
B. One (1) complete VFD Operator panel/keypad;
C. One complete set of VFD System fuses (line, load, control);
D. All spare parts shall be delivered prior to VFD System startup;

1.7 CONFIGURATION SOFTWARE AND CONNECTION CABLE

A. One (1) complete licensed Configuration, Control and Monitoring Microsoft® Windows™ Based Software and PC to Inverter Converter & Connection Cable shall be delivered prior to VFD System startup;

PART 2 - PRODUCTS

2.1 OWNER STANDARDIZATION

A. The Owner's SCADA Automation Architecture is based on SIEMENS INDUSTRY Automation hardware & software components and the distributed PROFIBUS® communications standard. Approximately two-thirds (2/3) of the Owner's existing and installed VFDs throughout the Owner's facilities are SIEMENS INDUSTRY or ROCKWELL AUTOMATION. The Owner has invested thousands of man-hours creating standards (control circuits, data structures, Programmable Logic Controller (PLC)/Human Machine Interface (HMI) programming objects and wiring diagrams) to

facilitate the integration of field devices into our SCADA Systems. The Owner has invested hundreds of man-hours training their personnel and thousands of dollars purchasing & stocking spare units and parts to maintain, trouble-shoot and repair these VFDs using “fully-tested” procedures and standards. The integration and development of another Manufacturer’s VFD product would vastly increase the integration efforts, maintenance costs and overall life-cycle costs for the Owner. Therefore, VFD components shall be as specified or chosen from Section 16370-2.04 or 16370-2.05 and assembled such that the intended function is achieved. In general, each VFD shall be equipped with a control unit, power module, operator panel/keypad and any additional components such as filters or reactors needed to comply with the Specifications and/or Contract Drawings.

B. For All Complete VFD Control Panel(s), the Owner’s latest “LOW VOLTAGE STANDARDS” (attached) shall be followed.

2.2 RATINGS

A. VFD(s) shall meet or exceed the ratings listed below, at a minimum:
   1. 1.3 to 477A; ½ to 400 HP (0.37kW to 250kW) VFD power range;
   2. 380- to 480VAC, +/-10%, three-phase rated input voltage;
   3. 47- to 63-Hertz rated frequency;
   4. 0.7 to .85 rated power factor;
   5. 95% inverter efficiency;
   6. High overload capability for 1.3 to 145A; ½ to 100 HP (0.37 to 75kW):
      a. 1.5-times rated output current (150% overload) for 57-seconds with a cycle time of 300-seconds;
      b. 2-times rated output current (200% overload) for 3-seconds with a cycle time of 300-seconds;
   7. High overload capability for 178 to 477A; 125 HP to 400 HP (90 to 200kW):
      a. 1.36-times rated output current (136% overload) for 57 seconds with a cycle time of 300 seconds;
      b. 1.6-times rated output current (160% overload) for 3 seconds with a cycle time of 300 seconds;
   8. NEMA 1 degree of enclosure protection;
   9. Operating temperature: 32 to 104 °F (0 to 40 °C) without derating;
   10. Storage temperature: -40 to 158 °F (-40 to 70 °C);
   11. Relative Humidity: <95% RH, non-condensing;
   12. Standard Protection Functions included: Under voltage, Over voltage, Over control/overload, Ground fault, Short circuit, Stall protection, Motor blocking protection, Motor over temperature, Inverter over temperature and Parameter locking;
   13. VFD product family shall be available in different mechanical sizes;
   14. UL Listing;

B. VFD(s) shall be Modular;
   1. VFD modularity ensures flexibility for the future;
   2. VFD shall have pluggable terminals;
   3. VFD modules can be easily replaced, which makes the VFD extremely service friendly;

4. The VFD shall be comprised of a variety of modular functional units (control unit, memory card, power module, operator keypad, filter, reactor, etc.);

C. VFD(s) Power Module (PM) supplies the motor in a power range of 1.3 to 477A; ½ to 400 HP (0.37 to 250kW);
   1. The PM is controlled by a microprocessor;
   2. State-of-the-art IGBT technology with six (6) pulse-width modulation (PWM) used to achieve the highest degree of reliability and flexible motor operation;
   3. The VFD shall use solid state electronics with a PWM output and the following:
      a. VFD shall have the capability of kinetic buffering that allows the VFD to “ride though” power dips without a controller trip depending on load and operating conditions;
      b. VFD shall have an electronic overload circuit designed to protect an AC motor operated by the VFD (this electronic overload shall be UL and NEC® recognized as adequate motor protection);
      c. The VFD shall include the following protective circuits:
         1) Phase to Ground short circuit condition;
         2) Output phase-to-phase short circuit condition;
         3) Total ground fault under any operating condition;
         4) High input line voltage;
         5) Low input line voltage;
         6) Loss of input or output phase;
         7) External fault;
      d. VFD shall not require additional hardware such as motor overload relays or motor thermostats to protect an AC motor;
      e. VFD shall have a removable operator panel (keypad) that can be programmed to display any analog value within the drive.
      f. VFD shall have 16 programmable fixed frequencies and 4 programmable skip frequencies;

D. VFD(s) Control Unit (CU) controls and monitors the PM and the connected motor using several different selectable control strategies;
   1. CU shall be powered via the PM or an external 24VDC source;
   2. CU shall have open-loop/closed-loop control techniques - voltage/frequency (V/f) linear/square/parameter, V/f with flux current control, Vector control with or without encoder, Torque control with or without encoder;
   3. CU shall include, as a minimum, six isolated discrete inputs, two scalable analog inputs (voltage or current), two analog outputs (voltage or current), three relay outputs and an encoder for speed feedback, all fully programmable;
   4. CU shall be capable of minor firmware upgrades using a local memory device;
   5. CU shall have a PID regulator for set point control;
   6. CU shall have the following internal functions available:
      a. Arithmetic - Add, Subtract, Multiply, Divide and Compare;
      b. Logic - AND, OR, XOR, NOT, Flip-Flop;

c. Timers;

7. The CU shall support communications, local and network, as an option (PROFIBUS® DP™ or PROFINET™);

E. VFD(s) Additional Components (a.k.a. Options) shall be provided, as required:

1. Operator panel/keypads – connected directly to the CU; remotely mounted, or handheld for mobility;
2. Line filters a.k.a. radio frequency interference (RFI) / electro-magnetic interference (EMI) filters – used to prevent interference with other sensitive electronic loads by reducing inverter emissions;
3. Line reactors – used to reduce the system perturbations caused by harmonics;
4. Braking resistors – used to dissipate excess energy in the DC link by use of an electronic switch (chopper);
5. Sine-wave filters – used to limit the rate of rise of voltage and the capacitive charging/discharging currents that usually occur with VFD operation (an output reactor is not required);
6. Output reactors – used to reduce the voltage stress on the motor windings; At the same time, the capacitive charging & discharging currents, which place an additional load on the PM when long motor cables are used, are reduced;

F. All Complete VFD Control Panel(s) in this project shall be provided with surge protection as specified in Section 16709 - Protectors and Surge Protection Devices (SPDs).

G. All Complete VFD Control Panel(s) in this project shall be provided in enclosures as specified on the Contract Drawings or as follows:

1. Indoors – NEMA 250, Type 12 with gasket, freestanding, enclosure for floor mounting, completely front accessible only and hinged doors. Properly sized to dissipate heat (even when assemblies are placed side-by-side with no gap between them) generated by controller within limits of specified operating conditions (including ambient temperature and ambient airflow). Enclosure shall be able to be tilted sideways to enter electrical room. VFD supplier shall verify before bidding space requirements of all VFD and possible active filtering equipment in electrical room. Coordinate any room layout modifications with Contractor before bidding.
2. Outdoors – NEMA 250, Type 4X 316 stainless steel with gasket, freestanding, enclosure for floor mounting, completely front accessible only and hinged doors. Properly sized to dissipate heat generated by controller within limits of specified operating conditions (including ambient temperature and ambient airflow). Provide additional cooling with a panel mounted air-conditioning unit. AC Unit shall be sized to maintain maximum inside temperature of 80 °F (27 °C). All external components shall be non-corrosive Type 316 stainless steel. Maintain NEMA 4X integrity of enclosure when mounting the cooling device.
3. Furnish drive complete with compartment door interlocked with main circuit breaker (defeatable) and lockable in the open position,

alphanumeric keypad and display, and operator's controls. VFD system shall have a UL label and ISO9001 certification.

4. Size forced-ventilation (front only) for continuous operation to cool each unit with maximum room ambient temperature of 95 degrees F.
5. Bundle stranded copper wiring neatly with nylon tie wraps or with continuous plastic spiral binding; label each terminal for permanent identification of leads; identify each wire at each end with imprinted Mylar adhesive-back wire markers; incorporate in as-installed wiring diagrams for wire and terminal numbers shown; wiring across door hinges use 19-strand, NEMA WC-57 Class C stranding looped for proper twist rather than bending at hinge; wire connections internal to panels by crimp-on terminal types. For multiple enclosure systems, complete interconnection wiring with enclosure openings with gaskets for wiring; multipoint plug receptacles for any control wiring crossing equipment shipping splits.
6. Drives shall fit within dimensions indicated. Maximum dimensions shall be as indicated on Contract Drawings.

H. The Owner has grouped, by cost, frame size and amperage, Acceptable Manufacturers product offerings in an effort to reduce spares;

ALLEN-BRADLEY® PowerFlex® 700	SIEMENS SINAMICS G120
34A; ½ to 20 HP (0.37 to 15kW); 2;	32A; ½ to 20 HP (0.37 to 15kW); FSC;
96A; 21 to 60 HP (16 to 45kW); 5;	90A; 21 to 60 HP (16 to 45kW); FSE;
156A; 61 to 100 HP (46 to 75kW); 6;	145A; 61 to 100 HP (46 to 75kW); FSF;
248A; 101 to 200 HP (76 to 132kW); 6;	250A; 101 to 200 HP (76 to 132kW); FSF;
481A; 201 to 400 HP (133 to 250kW); 8;	477A; 201 to 400 HP (133 to 250kW); FSGX;

PowerFlex® 700 Mechanical W x H x D inches (mm); lbs. (kg)
0 – 4.33 x 13.23 x 7.87 (110 x 336 x 200); 11.5 (5.22)
2 – 8.74 x 13.48 x 7.87 (222 x 342.5 x 200); 27.6 (12.52);
3 – 8.74 x 20.37 x 7.87 (222 x 517.5 x 200); 40.9 (18.55);
5 – 12.16 x 25.37 x 10.84 (308.9 x 644.5 x 275.4); 82 (37.19);
6 – 15.90 x 33.46 x 10.85 (403.9 x 850 x 275.5); 157.5 (71.44);
7 – 59 x 20.25 x 16.02 (1498.6 x 514.4 x 406.9); 375 (170);
8 – 93.46 x 29.83 x 35 (2373.9 x 757.7 x 889); 1122 (509);

SINAMICS G120 Mechanical W x H x D inches (mm); lbs. (kg)
FSB – 6.02 x 10.63 x 9.06 (153 x 270 x 230); 8.82 (4);
FSC – 7.44 x 13.15 x 9.84 (189 x 334 x 250); 15.43 (7);
FSD – 10.83 x 16.50 x 10.24 (275 x 419 x 260); 28.66 (13);
FSE – 10.83 x 19.65 x 10.24 (275 x 499 x 260); 35.27 (16);
FSF – 13.78 x 24.96 x 14.65 (350 x 634 x 372); 85.98 (39);
FSGX – 12.90 x 60.35 x 21.60 (326 x 1533 x 547); 383.60 (174);

2.3 ACCEPTABLE MANUFACTURERS

A. The listing of specific Manufacturers does not imply acceptance of their products that do not meet the specified ratings, features and functions.

Manufacturers listed are not relieved from meeting these specifications in their entirety.

B. All Complete Control Panel VFDs in this project shall be provided by the same Supplier as all electrical equipment. This Division 16 Electrical Supplier shall coordinate with the Division 11 Equipment Supplier(s) to ensure proper sizing, space, connections, terminating lugs, conduit entry requirements, cable, etc. The Electrical Supplier and the Division 11 Equipment Supplier(s) are required to provide written evidence of this "complete" coordination in their respective submittals. Submittals without this coordination shall be rejected.

C. All VFDs in this project shall be of the same Manufacturer and represented by their local factory-certified VFD Product Partner by Square D, Eaton, Allen Bradley or Siemens.

D. **Part numbers and model numbers included in this specification are provided for reference only to determine contract requirements, provide latest models of equivalent products as required.**

2.4 ROCKWELL AUTOMATION ALLEN-BRADLEY® POWERFLEX® 700

A. Control/Power Unit:
480VAC ±10%; Up to 481A (400 HP); 3ø, 60-Hertz;
Flange Mount (Front: IP00, NEMA/UL Type Open; Back/Heat sink: IP54, NEMA/UL Type 12);
Standard I/O comprised of 6 Discrete Inputs, 3 Discrete Outputs, 2 Analog Inputs, 2 Analog Outputs and 1 Encoder Input;

1. ROCKWELL AUTOMATION
www.ab.com
Part No. 20B D 034 N0ANNNNC0;
2. ROCKWELL AUTOMATION
www.ab.com
Part No. 20B D 096 N0ANNNNC0;
3. ROCKWELL AUTOMATION
www.ab.com
Part No. 20B D 156 N0ANNNNC0;
4. ROCKWELL AUTOMATION
www.ab.com
Part No. 20B D 248 N0ANNNNC0;
5. ROCKWELL AUTOMATION
www.ab.com
Part No. 20B D 481 N0ANNNNC0;

B. Communication Option Kits

1. ROCKWELL AUTOMATION
www.ab.com
Part No. 20-COMM-P;
PROFIBUS® DP™ Communication Adapter and PROFIBUS® DP™ Connector, Axial (Straight) – Used for VFD Connections,

C. Operator Panel/Keypad

1. ROCKWELL AUTOMATION
www.ab.com

Part No. 20-HIM-A6 with HAND/AUTO Pushbutton;
Human Interface Module (HIM) for Remote (Panel Mount) IP66, NEMA/UL Type 4x/12 for Indoor Use only, includes a 1202-C30 interface cable (3 meters);

D. Configuration, Control and Monitoring Microsoft® Windows™ Based Software, PC To Inverter Converter & Connection Cable
   1. ROCKWELL AUTOMATION
      www.ab.com
      Part No. 9306-4EXP02ENE and
      Part No. 1203-USB;
      DriveExplorer™ for PC full feature version and Universal Serial Bus™ Converter;

E. 5% IP11 Heavy Duty Line Reactor
   1. ROCKWELL AUTOMATION
      www.ab.com
      Part No. 1321-3RA…;

F. 5% IP11 Heavy Duty Output Reactor
   1. ROCKWELL AUTOMATION
      www.ab.com
      Part No. 1321-3RA…;

2.5 SIEMENS INDUSTRY SINAMICS G120 STANDARD INVERTER

A. Control Unit (CU):
   Standard I/O comprised of 9 Discrete Inputs, 3 Discrete Outputs, 2 Analog Inputs, 2 Analog Outputs and 1 Encoder Input;
   RS232 (CU240S, -PN or -DP);
   IP20;
   1. SIEMENS INDUSTRY
      www.sea.siemens.com
      Part No. 6SL3 244-0BB12-1BA1,
      Part No. 6SL3 254-0AM00-0AA0;
      LIFT STATION STANDARD G120 CU240E-2,
      Memory Card;
   2. SIEMENS INDUSTRY
      www.sea.siemens.com
      Part No. not released yet;
      Part No. 6SL3 254-0AM00-0AA0;
      PROFINET® STANDARD
      G120 CU240E-2 with PROFINET®,
      Memory Card;
   3. SIEMENS INDUSTRY
      www.sea.siemens.com
      Part No. 6SL3 244-0BB12-1PA1,
      Part No. 6SL3 254-0AM00-0AA0, and
      Part No. 6GK1 500-0EA02;
      PROFIBUS® DP™ STANDARD
      G120 CU240E-2 with PROFIBUS® DP™,
      Memory Card and

PROFIBUS® DP™ Axial (Straight) Connector;

B. Power Module (PM)
380… 480VAC ±10%; Up to 477A (400 HP); 3ø, 60-Hertz; IP20;
1. SIEMENS INDUSTRY
www.sea.siemens.com
Part No. 6SL3 224-0BE31-1UA0;
2. SIEMENS INDUSTRY
www.sea.siemens.com
Part No. 6SL3 224-0BE33-7UA0;
3. SIEMENS INDUSTRY
www.sea.siemens.com
Part No. 6SL3 224-0BE35-5UA0;
4. SIEMENS INDUSTRY
www.sea.siemens.com
Part No. 6SL3 224-0BE41-1UA0;
5. SIEMENS INDUSTRY
www.sea.siemens.com
Part No. 6SL3 224-0XE42-0UA0;

C. Operator Panel/Keypad
1. SIEMENS INDUSTRY
www.sea.siemens.com
KNORRTEC
www.knorrtec.de
Part No. 6SL3 255-0AA00-4CA1 with HAND/AUTO Pushbutton;
Part No. 6SL3 256-0AP00-0JA0;
KNORRTEC Part No. 10045200; and
KNORRTEC Part No. 2382566;

D. Configuration, Control and Monitoring Microsoft® Windows™ Based Software and PC to Inverter Connection Cable Kits
1. SIEMENS INDUSTRY
www.sea.siemens.com
Part No. 6SL3 255-0AA00-2CA0;
2. SIEMENS INDUSTRY
www.sea.siemens.com
Part No. 6SL3 255-0AA00-2AA1;

E. Line Reactor
1. SIEMENS INDUSTRY
www.sea.siemens.com
Part No. 6SL3 …;

F. Output Reactor
1. SIEMENS INDUSTRY
www.sea.siemens.com
Part No. 6S …;

PART 3 - INSTALLATION

3.1 DELIVERY

A. Upon delivery, the Contractor shall coordinate with the VFD Manufacturer or their local factory-certified VFD Product Partner to ensure a correct mechanical and electrical installation of the VFD and associated components.

3.2 INSTALLATION

A. The VFD Manufacturer shall have the local capability and personnel to assist in the start-up, training, service and maintenance of the VFD(s).
B. All VFD Control Panel(s) shall be installed per the Contract Drawings in accordance with the Manufacturer's recommendations.
C. Remove temporary lifting angles, lugs, and shipping braces.
D. The VFD Control Panel(s) shall be protected against damage at all times. Any damage to the paint shall be carefully repaired using touch-up paint furnished by Manufacturer.
E. The Contractor shall provide the technical services of the VFD Manufacturer or their local factory-certified VFD Product Partner, who shall supervise the installation, perform a certified VFD startup and testing of each VFD Control Panel(s) and accessories furnished under this Section and instruct the Owner's personnel in the correct operation of the VFD units.
F. All costs for transportation, lodging, subsistence, and other incidental costs for the VFD Manufacturer or their local factory-certified VFD Product Partner personnel during the installation, startup, testing, and instruction shall be by the Contractor at no cost to the Owner.
G. The Contractor shall install all VFD Control Panels in accordance with Manufacturer's installation instructions and the Contract Drawings. All panels shall be installed plumb vertically and horizontally within one degree.

3.3 ADJUSTING AND CLEANING

A. The VFD Control Panel(s) shall be adjusted accordingly per Manufacturer’s recommendations.
B. Clean exposed surfaces using Manufacturer recommended materials and methods.
C. Vacuum all interior spaces.

3.4 TESTING

A. Perform factory and installation tests in accordance with applicable NEC®, NEMA and UL requirements.

3.5 STARTUP SERVICES

A. The Contractor shall provide the following VFD Manufacturer or their local factory-certified VFD Product Partner Services, at a minimum:
    1. Two (2) person-days (a day equals 8-hours) for installation assistance and inspection;

2. Two (2) person-days for functional and performance testing and completion of VFD Manufacturer Certified VFD Startup and Certificate of Proper Installation;
3. One (1) person-day for facility startup (Two (2) additional trips shall be included for this work at days/times approved and selected by the Owner);

B. The initial Manufacturer Certified VFD Startup of each VFD delivered with the assistance of the Owner shall include the following, at a minimum:
1. Verify that the model numbers and the voltage ratings are as specified in the purchase order or Contract Drawings by matching the nameplate data for each VFD to the purchase order or Contract Drawings;
2. Verify that the VFD has been installed in accordance with the mechanical and electrical installation sections of the O&M Manual;
3. Inspect the security of the supply line power, ground connections, and all control circuit connections;
4. Review the “as wired” schematic and determine where the motor “safety circuit” is connected;
5. Verify that the emergency contacts are properly terminated in the VFD’s safety shutdown circuit;
6. Verify that all other field-installed wires are correctly terminated (including the shields);
7. Record the motor nameplate (voltage, power factor, full load amps, RPM, etc.) information;
8. Verify that the input voltage matches the VFD’s rating;
9. Verify that the motor is wired for the application voltage;
10. Record any other connections to the VFD by terminal number to determine if special configuration or programming is required;
11. Off-line, verify that the configuration is ready to perform adequately for start, stop and speed command functions;
12. Apply power to the VFD;
13. Make sure that the input voltage is correct for the system being set up;
14. Verify that the VFD display is on;
15. Download configuration;
16. Proceed with commissioning procedure;
17. Verify that the direction of motor rotation is correct;
18. Verify correct operation in HAND/LOCAL, OFF and AUTO/REMOTE modes;
19. Upload installed VFD configuration and provide a copy of the file to the Owner;
20. Manufacturer certified start-up form shall be filled out for each VFD started up with a copy provided to the Owner.

3.6 ON-SITE TRAINING

A. The VFD Manufacturer or their local factory-certified VFD Product Partner shall provide on-site training;
1. Minimum of four (4) hours of on-site training per each VFD supplied at time(s) and location(s) approved by the Owner;

2. Each student shall receive a “quick startup guide”, a listing of each VFD(s) switch configuration and parameterization and Trouble-shooting guide with Fault codes;
3. Any and all special tools, equipment training manuals used during the training shall be the property of the Owner upon completion of the training.

3.7 WARRANTY

A. Any VFD(s) or components that fail or perform incorrectly prior to warranty completion shall be replaced at no cost to the Owner.
B. The factory warranty shall include all parts related to the restoration of the failed component.
C. VFD Manufacturer shall guarantee the VFD and supporting components with a factory warranty to be free of defects in materials and workmanship for a period of two-years from date of Substantial Completion.

VFD PARAMETER SETUP CHECKLIST

[ENTER NAME OF FACILITY]

- ☐ 1. Ramp up speed _____
- ☐ 2. Ramp down speed _____
- ☐ 3. Min speed (Hz) _____
- ☐ 4. Max speed (Hz) _____
- ☐ 5. 4-20mA setting at min speed (mA) _____
- ☐ 6. 4-20mA setting at max speed (mA) _____
- ☐ 7. Output scale calibration _____
- ☐ 8. Auto restart after power failure (yes/no) _____
- ☐ 9. Auto restart after overcurrent fault (yes/no) _____
- ☐ 10. Speed reference (internal/external) _____
- ☐ 11. If external - signal source _____
- ☐ 12. If external - signal type _____
- ☐ 13. Restart after E-Stop (yes/no) _____
- ☐ 14. Discrete outputs - Run (yes/no) _____
- ☐ 15. Discrete outputs - Fault (yes/no) _____
- ☐ 16. Analog outputs - Amps (absolute units) _____
- ☐ 17. Analog outputs - KW (absolute units) _____
- ☐ 18. Analog outputs - Speed (Hz) _____
- ☐ 19. Analog outputs - Speed (RPM) _____
- ☐ 20. Analog inputs - 4mA set to 0Hz (yes/no) _____
- ☐ 21. Analog inputs - 20mA set to 60Hz (yes/no) _____
- ☐ 22. Analog inputs - min speed limit set (yes/no) _____
- ☐ 23. Analog inputs - max speed limit set (yes/no) _____
- ☐ 24. Voltage boost (%) _____
- ☐ 25. Starting frequency (Hz) _____
- ☐ 26. PMW carrier frequency (Hz) _____
- ☐ 27. Acceleration time (sec) _____
- ☐ 28. Deceleration time (sec) _____
- ☐ 29. Forward run (yes/no) _____
- ☐ 30. Reverse run (yes/no) _____
- ☐ 31. Overload (60%-100%)

VFD PARAMETER SETUP VERIFICATION

[ENTER NAME OF FACILITY]

Date: _____

General Contractor: _____

Electrical Subcontractor: _____

VFD Supplier: _____

This certifies that the VFD parameters have been coordinated per the specifications and the requirements of Section 16370.

(Authorized Representative of the General Contractor)	Date
(Authorized Representative of the Electrical Subcontractor)	Date
(Authorized Representative of the VFD Supplier)	Date

End Of Section

Section 16450

GROUNDING SYSTEM

PART 1 - GENERAL

1.1 SCOPE

A. This section includes materials, testing, and installation of electrical grounding.

B. Related Work Specified Elsewhere (if included):
   1. Division 1 – General Requirements;
   2. Division 2 – Site Work;
   3. Division 3 – Concrete;
   4. Division 11 – Equipment;
   5. Division 13 – Special Construction;
   6. Division 15 – Mechanical;
   7. Division 16 – Electrical;

C. All work shall be performed according to National Fire Prevention Association® (NFPA®) 780, National Electrical Code® (NEC®) Article 250, City's Lift Stations Standards Detail Sheets 902-908 and the City's Low Voltage Standards Detail Sheets 902-908;

D. Do not energize the electrical power system unless the system ground resistance is equal to or less than five (5) ohms.

1.2 REFERENCES

A. All characteristics, definitions, and terminology, except as specifically covered in this Specification, shall be in accordance with the latest revision of the following standards:
   1. American Society for Testing and Materials (ASTM) B-8 - Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft;
   2. ASTM B-33 Tinned Soft or Annealed Copper Wire;
   3. American National Standards Institute (ANSI) / Institute of Electrical and Electronics Engineers (IEEE) 142 - Recommended Practice for Grounding of Industrial and Commercial Power Systems;
   4. National Electrical Contractors Association (NECA) National Electrical Installation Standards (NEIS);
   5. NECA 1 - Standard Practice of Good Workmanship in Electrical Construction;
   6. NECA 331 - Standard for Building and Service Entrance Grounding and Bonding;
   7. National Fire Protection Association® (NFPA®) 70 – National Electrical Code® (NEC®);
   8. NEC® Article 250 – Grounding and Bonding;
   9. NFPA® 70E® - Electrical Safety in the Workplace;
   10. Underwriters Laboratories (UL) 467 - Grounding and Bonding Equipment;

1.3 SUBMITTALS

A. Submit shop drawings in accordance with the General Conditions and Section 01420.
B. All submittal documents shall be provided in both hardcopy, bounded in separate three-ring binders, indexed, tabbed with sectional dividers, and no larger than 8½-inch x 11-inch and bookmarked electronic media - Adobe® Acrobat® portable document format. Two sets of hardcopies and two sets of electronic media shall be provided.
C. All drawings shall be provided in both hardcopy, bounded, indexed, and no larger than 11-inch x 17-inch and bookmarked electronic media - Autodesk® AutoCAD® file format AND Adobe® Acrobat® portable document format. Two sets of hardcopies and two sets of electronic media shall be provided.
D. The following information, at a minimum, shall be submitted to the City:
    1. Descriptive bulletins;
    2. Product data sheets;
    3. Master drawing index;
    4. Dimensioned front & plan view of the assembly;
    5. Schematic diagram;
    6. Cable terminal sizes;
    7. Component list;
    8. Conduit space entry/exit locations;
    9. Ratings;
    10. Wiring diagrams;
    11. Installation information;
E. Submit material list for all grounding materials and equipment. Indicate size, material and Manufacturer;
F. Submit resistance reading for each ground rod;

1.4 QUALITY ASSURANCE

A. The Manufacturer shall have a minimum of ten (10) years consecutive experience producing similar electrical equipment.
B. The Manufacturer shall be ISO certified.
C. UL Listing Requirements
    1. “Manufactured in accordance with” is not equivalent to “UL LISTED” and does not meet the intent of this specification;
    2. The Grounding components shall be posted at www.UL.com under the appropriate Category Code. Products without posting at UL.com shall not be approved. To access UL Category Code, click on Certifications of UL’s home page. Type the appropriate code into the Category Code search box and click Search.

1.5 DELIVERY, STORAGE AND HANDLING

A. Deliver products and equipment in factory labeled packages that include recommended storage practices placed on the outside of the shipping container.

B. Handling and shipment of the products and equipment shall be in such a manner to prevent internal component damage, breakage, and denting and scoring of the enclosure finish.
C. Store and handle in strict compliance with Manufacturer's instructions and recommendations. Protect from potential damage from weather and construction operations. Store so condensation will not form on or in equipment and if necessary, apply temporary heat where required to obtain suitable service conditions.

PART 2 - PRODUCTS

2.1 GROUNDS RODS

A. All grounds rods shall be 10-mil Copper plated steel, ¾-inch diameter, minimum 20-feet long with hardened steel points;
B. All grounds rods shall be UL Listed;
C. Acceptable Ground Rod Manufacturers
   1. ERICO® PRODUCTS INC.
      www.erico.com
      Sectional Copperbonded Ground Rods,
      Part No. 633400;
      with Threaded Coupler,
      Part No. CR34;
   2. HARGER LIGHTNING & GROUNDING
      www.harger.com
      Copper Clad Steel Ground Rods, Part No. 3410;
      with Coupler,
      Part No. GRCC34;
   3. THOMPSON LIGHTNING PROTECTION, INC.
      www.tlpinc.com
      Sectional Copperclad,
      Part No. TL3410S;
      with Coupler,
      Part No. 70C;

2.2 BARE TINNED CONDUCTORS

A. Bare Copper wire shall not be used;
B. Conductors shall meet ASTM B-8 - Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft; B-33 Tinned Soft or Annealed Copper Wire;
C. Bare #2-Tinned, 7-Strand Conductors
D. Acceptable Bare Tinned Conductor Manufacturers
   1. HARGER LIGHTNING & GROUNDING
      www.harger.com
      7 Strand Concentric Lay Down, Soft-Drawn Bare Copper,
      Part No. 2-7T;
   2. NEHRING ELECTRICAL WORKS CO.
      www.nehringwire.com
      Stranded/Concentric Bare Tinned Copper;

E. Bare #2/0-Tinned, 19-Strand Conductors
F. Acceptable Bare #2/0-Tinned, 19-Strand Conductor Manufacturers
   1. HARGER LIGHTNING & GROUNDING
      www.harger.com
      19 Strand Concentric Lay Down, Soft-Drawn Bare Copper,
      Part No. 2/0-19T;
   2. NEHRING ELECTRICAL WORKS CO.
      www.nehringwire.com
      Stranded/Concentric Bare Tinned Copper;
G. Bare #4/0-Tinned, 19-Strand Conductors
H. Acceptable Bare #4/0-Tinned, 19-Strand Conductor Manufacturers
   1. HARGER LIGHTNING & GROUNDING
      www.harger.com
      19 Strand Concentric Lay Down, Soft-Drawn Bare Copper,
      Part No. 4/0-19T;
   2. NEHRING ELECTRICAL WORKS CO.
      www.nehringwire.com
      Stranded/Concentric Bare Tinned Copper;
I. Bare Tinned Bonding Jumper Braid
   1. Tinned copper braided tape, constructed of 30-gauge bare copper wires, #4 AWG unless noted to be #2 or #1/0;
   2. Terminate with flat two-hole lug;
J. Acceptable Bare Tinned Bonding Jumper Braid Manufacturers
   1. BURNDY®
      www.burndy.com
      Un-insulated Copper Braid;
   2. HARGER LIGHTNING & GROUNDING
      www.harger.com
      Tinned Copper Flat-Braid Conductor,
      Part No. CUFBxxxxxT;
K. Bare Tinned Flexible Jumper Strap
   1. Tinned flexible fat conductor, 480 strands of 30-gauge bare copper wires, ¾-inch wide, 9-½-inch long, 48.250 circular mil;
   2. Select braid with holes sized for 3/8-inch diameter bolts and protect the braid with copper bolt-hole ends; Terminate with flat two-hole lug;
L. Acceptable Bare Tinned Flexible Jumper Strap Manufacturers
   1. BURNDY®
      www.burndy.com
      Grounding Products;
   2. HARGER LIGHTNING & GROUNDING
      www.harger.com
      Tinned Copper Flat-Strap Conductor,
      Part No. CUFSxxxxxT;

2.3 CONNECTORS

A. Connect grounding conductors with connectors using the exothermic reaction where feasible, otherwise use mechanical type connector, split-bolt, saddle or cone screw type, copper alloy material;
B. Exothermic Weld Ground Rod Clamps
C. Acceptable Exothermic Weld Ground Rod Clamp Manufacturers
   1. BURNDY®
      www.burndy.com
      BURNDYWeld®;
   2. ERICO® PRODUCTS INC.
      www.erico.com
      CADWELD® Electrical Grounding and Bonding;
   3. HARGER LIGHTNING & GROUNDING
      www.harger.com
      Ultraweld®;
D. Disconnecting Ground Rod Clamps
   1. Cast bronze with at least two stainless steel bolts;
E. Acceptable Disconnecting Ground Rod Clamp Manufacturers
   1. HARGER LIGHTNING & GROUNDING
      www.harger.com
      Ground Rod Clamp,
      Part No. 302;
   2. INDEPENDENT PROTECTION CO., INC.
      www.ipclp.com
      Ground Rod Clamp,
      Part No. 52A;

2.4 GROUND WELL WITH COVER

A. For use in non-vehicular traffic situations only; Not for installation in concrete or asphalt; "GROUND" embossed on cover; Approx. 13-inch x 24-inch x 18-inch Deep;
B. Acceptable Ground Well with Cover Manufacturers
   1. ERICO® PRODUCTS INC.
      www.erico.com
      Polymer Concrete Inspection Well, Part No. T416A;
   2. HARGER LIGHTNING & GROUNDING
      www.harger.com
      Polymer Concrete Inspection Well, Part No. GAW132418HD;

2.5 GROUNDING MISCELLANEOUS MATERIALS

A. For other components not specified, yet needed;
B. Acceptable Grounding Miscellaneous Materials Manufacturers
   1. ERICO® PRODUCTS INC.
      www.erico.com
      ERITECH® Grounding Products;
   2. HARGER LIGHTNING & GROUNDING
      www.harger.com
      Grounding & Bonding Products;

PART 3 - EXECUTION

3.1 GROUNDING ELECTRODE SYSTEM

A. Bond the following together to form the grounding electrode system:
   1. The ground rod and counterpoise installation;
   2. All existing ground conductor installations;
   3. All enclosures;
   4. The ground ring (counterpoise) encircling the light pole;
   5. The fence surrounding the area;
   6. Concrete encased re-bar;

3.2 MAIN SYSTEM GROUND REQUIREMENTS

A. Install a ground conductor from the main distribution panel or switchboard to the grounding electrode system.

B. Provide ground rod installation and make exothermic connections at all pad-mounted transformers, pad-mounted switches, manholes, handholds and light poles.

3.3 EQUIPMENT GROUNDING METHODS

A. Install a separate ground conductor in all raceways. This separate ground conductor is in addition to the shield, drain and ground wires of multi-conductor cables for power, control, instrumentation and telemetry.

B. At all electrical equipment, install insulated throat grounding bushings on all conduits and a lug on the panel back box and bond conduits and back box together using a #4 AWG minimum copper conductor. Bond junction boxes in feeder conduit runs in a similar manner.

C. At outlet, junction and pull boxes, install a grounding jumper from box ground screw to equipment or device ground terminal.

3.4 SPECIAL SYSTEM GROUNDING

A. For telephone, alarm, and communication systems provide a #4 AWG minimum copper conductor from the grounding electrode system to each terminal cabinet or equipment location;

3.5 DRY-TYPE TRANSFORMER GROUNDING

A. Ground the neutral of each dry-type transformer to the grounding electrode system using a separate conductor, size #2/0 AWG or larger.

3.6 GROUND TEST WELL

A. Provide a handhold and ground rod test well to aid in performing ground testing and connecting additional depth of ground rods if required by the test results.
   1. Connect ground wire from ground rod to main service switchboard ground bus.
   2. Test wells to be located at all installations where a counterpoise is installed, and also as shown on the drawings.

3.7 GROUND WIRE INSTALLATION

A. Provide and install Bare Tinned Copper Conductor for all underground wire.

3.8 TESTS

A. Before making connections to the ground electrodes, measure the resistance of each electrode to ground using a ground resistance tester. Perform the test not less than two days after the most recent rainfall, and in the afternoon after any ground condensation (dew) has evaporated.
B. After all individual ground electrode readings have been made, interconnect as required and measure the system's ground resistance.
C. Record and submit all measured values to City.
D. Do not energize the electrical power system unless the system ground resistance is less than 5 ohms.

3.9 WARRANTY

A. Equipment Manufacturer warrants that all goods supplied are free of non-conformities in workmanship and materials for one year from date of Substantial Completion.

End of Section

Section 16500

LIGHTING SYSTEM

PART 1 - GENERAL

1.1 SCOPE

A. Furnish and install complete lighting systems including panelboards, transformers, lighting fixtures, receptacles, switches, contactors, and all necessary accessories and appurtenances required as herein specified and shown on the Contract Drawings.

B. Related Work Specified Elsewhere (if included):
   1. Division 1 – General Requirements;
   2. Division 2 – Site Work;
   3. Division 3 – Concrete;
   4. Division 11 – Equipment;
   5. Division 13 – Special Construction;
   6. Division 15 – Mechanical;
   7. Division 16 – Electrical;
      a. Section 16010 - Electrical – General Provisions
      b. Section 16050 - Basic Electrical Materials and Methods;
      c. Section 16108 – Miscellaneous Equipment;
      d. Section 16110 - Raceways, Boxes and Fittings for conduit;
      e. Section 16120 - Wires and Cables – 600-Volt and Less;
      f. Section 16160 – Panelboards;
      g. Section 16190 - Supporting Devices;
      h. Section 16450 - Grounding System;
      i. Section 16670 - Lightning Protection System (LPS);
      j. Section 16709 - Protectors and Surge Protection Devices (SPDs);
      k. Section 16950 - Electrical Testing;

C. All lighting fixtures shall be in accordance with the NEC® and be constructed in accordance with UL 1598 latest edition;

D. All fixtures and devices shall be UL Listed and labeled;

E. All luminaries shall be manufactured by the same Manufacturer, no exceptions;

F. The City has specified light-emitting diode (LED) lighting (4000K to 5000K) systems for environmental (mercury-free products, reduce carbon emissions, etc.) & economical (reduce lighting energy costs by as much as 80% and drastically reduce lighting maintenance costs) reasons.

1.2 REFERENCES

A. All characteristics, definitions, and terminology, except as specifically covered in this Specification, shall be in accordance with the latest revision of the following standards:
   1. National Electrical Contractors Association (NECA) National Electrical Installation Standards (NEIS);

2. NECA 1 - Standard Practice of Good Workmanship in Electrical Construction;
3. NECA 500 - Standard for Installing Indoor Lighting Systems;
4. NECA 501 - Standard for Installing Exterior Lighting Systems;
5. NECA 502 - Standard for Installing Industrial Lighting Systems;
6. NECA 505 - Standard for Installing and Maintaining High Mast, Roadway and Area Lighting;
7. National Electrical Manufacturers Association (NEMA) WD 1 - General Color Requirements for Wiring Devices;
8. National Fire Protection Association® (NFPA®) 70 – National Electrical Code® (NEC®);
9. NEMA WD 6 - Wiring Devices—Dimensional Specifications;
10. NFPA® 70E® - Electrical Safety in the Workplace;
11. Underwriters Laboratories (UL) 20 - General-Use Snap Switches;
12. UL 66 - Fixture Wire;
13. UL 542 - Lamp holders, Starters, and Starter Holders for Fluorescent Lamps;
14. UL 773 – Plug-In Locking Type Photo-controls for Use with Area Lighting;
15. UL 773A - Nonindustrial Photoelectric Switches for Lighting Control;
16. UL 844 - Luminaries for Use in Hazardous (Classified) Locations;
17. UL 924 - Emergency Lighting and Power Equipment;
18. UL 935 - Fluorescent Lamp Ballasts;
19. UL 1029 - High-Intensity-Discharge Lamp Ballasts;
20. UL 1570 – Fluorescent Lighting Fixtures;
21. UL 1572 – High Intensity Discharge Lighting Fixtures;
22. UL 1598 - Luminaries;
23. UL 1598C – Light Emitting Diode (LED) Retrofit Luminaire Conversion Kits;
24. UL 8750 - Light Emitting Diode (LED) Equipment for Use in Lighting Products;

1.3 SUBMITTALS

A. Submit shop drawings in accordance with the General Conditions and Section 01420.

B. All submittal documents shall be provided in both hardcopy, bounded in separate three-ring binders, indexed, tabbed with sectional dividers, and no larger than 8½-inch x 11-inch and bookmarked electronic media - Adobe® Acrobat® portable document format. Two sets of hardcopy and two sets of electronic media shall be provided.

C. All drawings shall be provided in both hardcopy, bounded, indexed, and no larger than 11-inch x 17-inch and bookmarked electronic media - Autodesk® AutoCAD® file format AND Adobe® Acrobat® portable document format. Two sets of hardcopy and two sets of electronic media shall be provided.

D. The following information, at a minimum, shall be submitted to the City:
   1. Descriptive bulletins;
   2. Product data sheets;

3. Master drawing index;
4. Dimensioned front & plan view of the assembly;
5. Schematic diagram;
6. Cable terminal sizes;
7. Component list;
8. Conduit space entry/exit locations;
9. Ratings;
10. Wiring diagrams;
11. Installation information;

1.4 QUALITY ASSURANCE

A. The Manufacturer shall have a minimum of ten (10) years consecutive experience producing similar electrical equipment.
B. The Manufacturer shall be ISO certified.
C. UL Listing Requirements
   1. "Manufactured in accordance with" is not equivalent to "UL LISTED" and does not meet the intent of this specification;
   2. The Lighting products shall be posted at www.UL.com under the appropriate Category Code. Products without posting at UL.com shall not be approved. To access UL Category Code, click on Certifications of UL's home page. Type the appropriate code into the Category Code search box and click Search.

1.5 DELIVERY, STORAGE AND HANDLING

A. Deliver products and equipment in factory labeled packages that include recommended storage practices placed on the outside of the shipping container.
B. Handling and shipment of the products and equipment shall be in such a manner to prevent internal component damage, breakage, and denting and scoring of the enclosure finish.
C. Store and handle in strict compliance with Manufacturer's instructions and recommendations. Protect from potential damage from weather and construction operations. Store so condensation will not form on or in equipment and if necessary, apply temporary heat where required to obtain suitable service conditions.

1.6 SPARE PARTS

A. Spare lamps shall be provided for all fixture types, except LED, supplied. The quantity of each type of lamp shall be 15% of the total used on the project, with a minimum of two;

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. The listing of specific Manufacturers does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed are not relieved from meeting these specifications in their entirety.

2.2 WALL SWITCHES

A. Reference SECTION 16050 - Basic Electrical Materials and Methods, 16050-2.49. Wall Switches for specifics;

2.3 STRAIGHT-BLADE RECEPTACLES

A. Reference SECTION 16050 - Basic Electrical Materials and Methods, 16050-2.50. Straight-Blade Receptacles for specifics;

2.4 DEVICE PLATES

A. Reference SECTION 16050 - Basic Electrical Materials and Methods, 16050-2.51. Device Plates for specifics;

2.5 INTERIOR/EXTERIOR INDUSTRIAL BULKHEAD AREA LUMINARIES

A. Features include:
   1. Low power consumption;
   2. Instant on/off response;
   3. Weather/corrosion resistant lamp assembly and housing;
   4. 120/277VAC, 60-Hertz;
   5. Resistant to shock and vibration;
   6. 5-Year Warranty;
   7. 70% lumen maintenance over 60,000 operating hours;
   8. NEMA 4X (IP66);
   9. UL1598;

B. Acceptable Interior/Exterior Industrial Bulkhead Area Luminaire Manufacturers;
   1. DIALIGHT CORPORATION
      www.dialight.com
      DuroSite™ STW Series LED Wallpack / Area Light Fixtures;
      Ideally suited for stairwells, platforms, exit, walkway, tunnel, subway and other industrial environments;
   2. City Preapproved Equal

2.6 INTERIOR/EXTERIOR INDUSTRIAL DOWN-LIGHT AREA LUMINARIES

A. Features include:
   1. Low power consumption;
   2. Instant on/off response;
   3. Weather/corrosion resistant lamp assembly and housing;
   4. 120/277VAC, 60-Hertz;
   5. Resistant to shock and vibration;
   6. 5-Year Warranty;
   7. 70% lumen maintenance over 100,000 operating hours;
   8. UL1598;
   9. Operating Temp: -40°F to +149°F (-40°C to +65°C)

B. Acceptable Interior/Exterior Industrial Down-light Area Luminaire Manufacturers
   1. DIALIGHT CORPORATION
      www.dialight.com
      DuroSite™ RTO Series LED White Down-light Fixtures;

a.k.a. Jelly Jar lamps
Ideally suited for stairwells, platforms, exit, walkway, tunnel, subway and other industrial environments;

2. City Preapproved Equal

2.7 INTERIOR/EXTERIOR INDUSTRIAL HIGH BAY LUMINARIES

A. Features include:
1. Low power consumption;
2. Instant on/off response;
3. Weather/corrosion resistant lamp assembly and housing;
4. Polycarbonate lens for wet environments, Tempered glass lens for others;
5. 120/277VAC or 347-480VAC, 60-Hertz;
6. Resistant to shock and vibration;
7. 5-Year Warranty;
8. 80% lumen maintenance after 60,000 hours;
9. NEMA 4X (IP66);
10. UL1598;

B. Acceptable Interior/Exterior Industrial High Bay Luminaire Manufacturers
1. DIALIGHT CORPORATION
www.dialight.com
DuroSite™ Series LED High Bay Fixtures with Occupancy Sensor and/or Dimming Options;
Ideal for warehouse, garage, aisle, cold storage, bridge, tunnel and general area lighting;
2. City Preapproved Equal

2.8 INTERIOR/EXTERIOR INDUSTRIAL LINEAR LUMINARIES

A. Features include:
1. Low power consumption;
2. Instant on/off response;
3. Weather/corrosion resistant lamp assembly and housing;
4. 120/277VAC, 60-Hertz;
5. Resistant to shock and vibration;
6. 10-Year Warranty;
7. >70% lumen maintenance over 100,000 operating hours;
8. IP65;
9. UL1598;
10. Operating Temp: -40°F to +149°F (-40°C to +65°C)

B. Acceptable Interior/Exterior Industrial Linear Luminaire Manufacturers
1. DIALIGHT CORPORATION
www.dialight.com
DuroSite™ LTM Series LED Linear Fixtures, Cool White with Wide Optics;
Rugged and durable for demanding industrial and utility lighting applications;
2. City Preapproved Equal

2.9 INTERIOR/EXTERIOR HAZARDOUS LOCATION BULKHEAD AREA LUMINARIES

A. Features include:
1. Low power consumption;
2. Instant on/off response;
3. Mercury Free;
4. 120/277VAC, 60-Hertz;
5. Resistant to shock and vibration;
6. 5-Year Warranty;
7. 70% lumen maintenance over 100,000 operating hours;
8. UL 844;
9. Ex II 2G D Ex d e mb IIC T6 Gb; w Ex tb IIIC T85° Db;
10. ATEX Zones 1 & 21 and 2 & 22;
11. IP66 & IP67;
12. Operating Temp: -40°F to +149°F (-40°C to +65°C)

B. Acceptable Interior/Exterior Hazardous Location Bulkhead Area Luminaire Manufacturers
1. DIALIGHT CORPORATION
www.dialight.com
SafeSite® HZ Series LED Wallpack / Bulkhead Fixtures;
Ideally suited for stairwells, platforms, exit, walkway, tunnel, subway and other industrial environments
2. City Preapproved Equal

2.10 INTERIOR/EXTERIOR HAZARDOUS LOCATION DOWN-LIGHT AREA LUMINARIES

A. Features include:
1. Low power consumption;
2. Instant on/off response;
3. Weather/corrosion resistant lamp assembly and housing;
4. 120/277VAC, 60-Hertz;
5. Resistant to shock and vibration;
6. 5-Year Warranty;
7. 70% lumen maintenance over 100,000 operating hours;
8. NEMA 4X (IP66);
9. Class I, Division 2, Groups A, B, C, D;
10. Operating Temp: -40°F to +149°F (-40°C to +65°C)
11. Hazardous environments T3C rated (-40 °C - +55 °C);
12. UL844 / UL1598;

B. Acceptable Interior/Exterior Hazardous Location Down-light Area Luminaire Manufacturers
1. DIALIGHT CORPORATION
www.dialight.com
SafeSite® Series RTO LED White Down-light Fixtures;
a.k.a. Jelly Jar lamps
Ideally suited for stairwells, platforms, exit, walkway, tunnel, subway and other industrial environments;
2. City Preapproved Equal

2.11 INTERIOR/EXTERIOR HAZARDOUS LOCATION HIGH BAY LUMINARIES

A. Features include:
   1. Low power consumption;
   2. Instant on/off response;
   3. Weather/corrosion resistant lamp assembly and housing;
   4. 120-277VAC, 60-Hertz;
   5. Resistant to shock and vibration;
   6. 5-Year Warranty;
   7. 70% lumen maintenance over 100,000 operating hours;
   8. NEMA 4X (IP66);
   9. Class I, Division 2, Groups A, B, C, D;
   10. Hazardous environments T3C rated (-40 °C - +55 °C);
   11. UL 844 / UL1598;

B. Acceptable Interior/Exterior Hazardous Location High Bay Luminaire Manufacturers
   1. DIALIGHT CORPORATION
      www.dialight.com
      SafeSite® Series LED High Bay Fixtures;
      Ideal for warehouse, garage, aisle, cold storage, bridge, tunnel and general area lighting;
   2. City Preapproved Equal

2.12 INTERIOR/EXTERIOR HAZARDOUS LOCATION LINEAR LUMINARIES

A. Features include:
   1. Low power consumption;
   2. Instant on/off operation;
   3. 100/277VAC,60-Hertz;
   4. Mercury Free;
   5. Resistant to shock and vibration;
   6. Temperature compensation technology for longer life;
   7. 10-Year Warranty;
   8. 70% lumen maintenance over 100,000 operating hours;
   9. NEMA 4X (IP66);
   10. Class I, Div 2;
   11. UL 1598A;
   12. Operating Temp: -40°F to +149°F (-40°C to +65°C

B. Acceptable Interior/Exterior Hazardous Location Linear Luminaries Manufacturers
   1. DIALIGHT CORPORATION
      www.dialight.com
      SafeSite™ LSD Series LED Linear Fixtures;
      Designed specifically to replace fluorescent lighting fixtures in industrial and hazardous location applications;
   2. City Preapproved Equal

2.13 EXTERIOR AREA/STREET LIGHTS

A. Features include:
   1. Low power consumption;

2. Instant on/off response;
3. Weather/corrosion resistant lamp assembly and housing;
4. Universal power inputs;
5. Resistant to shock and vibration;
6. Field replaceable power supply;
7. Built-in thermal overload protection circuitry;
8. 5-Year Warranty;
9. UL1598;
10. UL 8750;

B. Acceptable Exterior Area/Street Lights Manufacturers
1. DIALIGHT CORPORATION
www.dialight.com
StreetSense™ Series LED Street Light Fixtures with Photo Controller Option;
Designed for easy installation & maintenance;
2. City Preapproved Equal

C. Exterior Concrete Poles:
1. Type I Pre-stressed Octagon concrete pole;
2. 20-foot length, 4-inch tip minimum, 7.25-inch butt minimum; or per Contract Drawings;
3. All corners chamfered, smooth surface, no cracks;
4. 7,000 PSI concrete;
5. Handhold shall measure 3-inch Deep x 6-inch Wide x 8-inch Height minimum; or per Contract Drawings;
6. Two cable entrances to internal raceway with couplings shall be cast in all poles 90 degrees to the handhold; or per Contract Drawings;
7. A PVC conduit for a ground wire shall be included parallel to raceway;
8. Include concrete collar as required by the Luminaire Manufacturer and Wind Load Calculations;
9. Lighting assembly to be certified per Florida Building Code;
10. Contractor shall submit signed and sealed Wind Load Calculations from a Structural Engineer licensed in the State of Florida;
11. City to select Color & Finish;
12. Pole shall be sealed with anti-graffiti coating;

D. Acceptable Exterior Concrete Pole Manufacturers
1. LONESTAR PRESTRESS MFG. INC.
www.lonestarprestress.com
Type I Pole;
Typical part nos. are comprised based on total length, type of pole based on strength & engineering, fixture mounting, brackets and color & finish;
2. PRE-CAST SPECIALTIES, INC.
www.precastspecialties.com
Type I Pole;
Typical part nos. are comprised based on total length, type of pole based on strength & engineering, fixture mounting, brackets and color & finish;

3. City Preapproved Equal

E. Exterior Aluminum Poles:
1. Seamless round extruded aluminum tube, welded aluminum top and bottom;
2. 12-foot length, 4-inch round minimum; or per Contract Drawings;
3. Smooth surface, no cracks;
4. All anchoring hardware shall be stainless steel;
5. Handhold shall be 18" up from base, with a gasketed cover and ground lug; or per Contract Drawings;
6. Two cable entrances to internal raceway with couplings shall be in all poles 90 degrees to the handhold; or per Contract Drawings;
7. A PVC conduit for a ground wire shall be included parallel to raceway;
8. Include appropriate collar as required by the Luminaire Manufacturer and Wind Load Calculations;
9. Lighting assembly to be certified per Florida Building Code;
10. Contractor shall submit signed and sealed Wind Load Calculations from a Structural Engineer licensed in the State of Florida;
11. City to select Color & Finish;
12. Pole shall be sealed with anti-graffiti coating;

F. Acceptable Exterior Aluminum Pole Manufacturers
1. HAPCO
www.hapco.com
Round Straight Aluminum,
RSA Pole Series;
2. KIM LIGHTING, INC.
www.kimlighting.com
Round Aluminum (Non-Tapered),
PRA Pole Series;
3. City Preapproved Equal

2.14 EMERGENCY LIGHTING COMMERCIAL SINGLE/TWO FACE THERMOPLASTIC EXIT 120/277VAC LIGHT WITH NICAD BATTERY;

A. Features include:
1. Universal mounting (wall, ceiling or end—canopy provided) installation;
2. 5-Year Warranty;
3. Life Safety NFPA 101;
4. UL 924 Listed;
5. UL listed for Damp Location use;

B. Acceptable Emergency Lighting Commercial Single/Two Face Thermoplastic Exit 120/277VAC Light with NiCad Battery Manufacturers
1. PHILIPS CHLORIDE
www.chloridesys.com
Commercial Exit Signs, CXX Series - COMPAC Thermoplastic LED Exit with Xtest™ Self-Diagnostics,
Part No. CXXL-3-R-W-DR, where
CXXL = LED Emergency with Xtest™ Diagnostics, NiCad Battery;
3 = Universal (includes extra stencil face plate);
R = Red Panel Color;

W = White Housing Color;
DR = Damp Location Rating;

2. City Preapproved Equal

2.15 EMERGENCY LIGHTING INDUSTRIAL SINGLE FACE CLASS I & II, DIVISION 2 EXIT 120/277VAC LIGHT WITH NICAD BATTERY;

A. Features include:
1. 5-Year Warranty (excluding lamps);
2. Life Safety NFPA 101;
3. UL 924 and UL 844 Listed;
4. UL Listed for Class I, Division 2, Groups A, B, C & D; Class I, Zone 2, Groups IIA, IIB (+H2) & IIC; and Class II, Division 2, Groups F & G;
5. Provides a minimum of 90-minutes of emergency power;

B. Acceptable Emergency Lighting Industrial Single Face Class I & II, Division 2 Exit 120/277VAC Light with NiCad Battery Manufacturers
1. PHILIPS CHLORIDE
www.chloridesys.com
Hazardous Emergency HZ Series, Class I & II, Division 2 Exit Sign
Part No. HZNRICT, where:
HZ = Hazardous Location LED Exit Series;
N = Nickel Cadmium Battery;
R = Red LED Letter Color;
IC = Intelli-Charge Diagnostics Model;
T = Self-Testing Diagnostics Option;
2. City Preapproved Equal

2.16 EMERGENCY LIGHTING INDUSTRIAL SINGLE FACE NEMA 4X EXIT LIGHT COMBO 120/277VAC WITH NICAD BATTERY;

A. Features include:
1. 5-Year Warranty;
2. Life Safety NFPA 101;
3. UL 924 Listed;
4. UL Listed for wet locations;

B. Acceptable Emergency Lighting Industrial Single Face NEMA 4X Exit Light 120/277VAC with NiCad Battery Manufacturers
1. PHILIPS CHLORIDE
www.chloridesys.com
Industrial Exit Signs, NEMA Series Harsh Environment Combo,
Part No. N2HLRW, where
N2H = Two Head Combination Series, Lead Calcium Battery;
L = LED Lamp Type;
R = Red LED Stencil Face/Letter Color;
W = Wet Location Listing;
CH-40500
2. City Preapproved Equal

2.17 EMERGENCY LIGHTING INDUSTRIAL SINGLE FACE CLASS I & II, DIVISION 2 EXIT LIGHT COMBO 120/277VAC WITH NICAD BATTERY;

A. Features include:
   1. 5-Year Warranty (excluding lamps);
   2. Life Safety NFPA 101;
   3. UL 924 and UL 844 Listed;
   4. UL Listed for Class I, Division 2, Groups A, B, C & D; Class I, Zone 2, Groups IIA, IIB (+H2) & IIC; and Class II, Division 2, Groups F & G;
   5. Provides a minimum of 90-minutes of emergency power;

B. Acceptable Emergency Lighting Industrial Single Face Class I & II, Division 2 Exit Light Combo 120/277VAC with NiCad Battery Manufacturers
   1. PHILIPS CHLORIDE
      www.chloridesys.com
      Hazardous Emergency HZ Series, Class I & II, Division 2 Combo,
      Part No. HZ636R2ZYICT, where:
      HZ = Hazardous Location LED Exit Series;
      6 = 6VDC System Voltage;
      36 = 36-watt Lead Calcium Battery;
      R = Red LED Letter Color;
      2 = Quantity of Lamp Heads;
      ZY = 6-watt Halogen Lamp Heads;
      IC = Intelli-Charge Diagnostics Model;
      T = Self-Testing Diagnostics Option;
   2. City Preapproved Equal

2.18 COMMERCIAL COMPACT NON-METALLIC, CORROSION RESISTANT EMERGENCY LIGHTING 120/277VAC UNIT WITH NICAD BATTERY

A. Features include:
   1. Low profile meets ADA specifications on lighting fixtures;
   2. 5-Year Warranty;
   3. NFPA 70;
   4. Life Safety NFPA 101;
   5. UL 924 Listed;

B. Acceptable Commercial Compact Non-Metallic, Corrosion Resistant Emergency Lighting 120/277VAC Unit with NiCad Battery Manufacturers
   1. PHILIPS CHLORIDE
      www.chloridesys.com
      Commercial Emergency CAX6 Series COMPAC® Semi-Recessed Head Thermoplastic Emergency Unit with Xtest™,
      Part No. CAX6NH-DR, where
      CAX6NH = 6VDC, NiCad Battery, white housing, 8 watt halogen MR16 lamps;
      DR = Damp Rating;
   2. City Preapproved Equal

2.19 INDUSTRIAL NON-METALLIC, CORROSION RESISTANT NEMA 4X EMERGENCY LIGHTING 120/277VAC UNIT WITH NICAD BATTERY

A. Features include:

1. 5-Year Warranty (excluding lamps);
2. Life Safety NFPA 101;
3. UL 924 Listed;
4. UL Listed for wet locations;

B. Acceptable Industrial Non-Metallic, Corrosion Resistant NEMA 4X Emergency Lighting 120/277VAC Unit with NiCad Battery Manufacturers

1. PHILIPS CHLORIDE
   www.chloridesys.com
   Industrial Emergency 4X Series,
   Part No. 4X6N50J962W, where
   4X = 4X Series;
   6 = 6VDC;
   N = Nickel Cadmium Battery;
   50 = 50-watt DC Wattage;
   J96 = 6V, 9-watt;
   2 = Quantity of Lamp Heads;
   W = UL Wet Location Listing;
2. City Preapproved Equal

2.20 INDUSTRIAL NON-METALLIC, CLASS I & II, DIVISION 2 EMERGENCY LIGHTING 120/277VAC UNIT WITH BATTERY;

A. Features include:

1. 5-Year Warranty (excluding lamps);
2. Life Safety NFPA 101;
3. UL 924 and UL 844 Listed;
4. UL Listed for Class I, Division 2, Groups A, B, C & D; Class I, Zone 2, Groups IIA, IIB (+H2) & IIC; and Class II, Division 2, Groups F & G;
5. Wall-mount;
6. Provides a minimum of 90-minutes of emergency power;

B. Acceptable Industrial Non-Metallic, Class I & II, Division 2 Emergency Lighting 120/277VAC Unit with NiCad Battery Manufacturers

1. PHILIPS CHLORIDE
   www.chloridesys.com
   Hazardous Emergency Steel-Lite Series, Class I & II, Division 2 Emergency Unit,
   Part No. STC100ZK2ICT, where:
   STC100 = 100-watt 12V, Lead Calcium Series;
   ZK = 8-watt 12VDC Halogen Lamp Heads;
   2 = Quantity of Lamp Heads;
   IC = Intelli-Charge Diagnostics Model;
   T = Self-Testing Diagnostics Option;
2. City Preapproved Equal

2.21 INTERIOR COMMERCIAL LOCATION T8 FLUORESCENT FIXTURE UPGRADE TO LED

A. Features include:

1. 100/277VAC,60-Hertz, +/-10%, Internal Driver;
2. Lamps fit into existing linear fluorescent fixtures (G13);

3. UL 1598C compliance (ensures the fixture maintains original UL compliance);
4. Glass free;
5. 5-Year Limited Warranty;

B. Acceptable Interior Commercial Location T8 Fluorescent Fixture Upgrade to LED Manufacturers
1. PHILLIPS LIGHTING COMPANY
www.philips.com
COREPRO LED Lamps
2. OSRAM SYLVANIA
www.sylvania.com
Commercial Grade LED T8 Lamps

2.22 LAMPS

A. Non-LED Lamps are for existing installations and control panel enclosures only;
1. Linear Fluorescent (FL);
2. Compact Fluorescent (CFL);
3. High-Intensity Discharge (HID);
4. High Pressure Sodium (HPS);
5. Light-Emitting Diode (LED);

B. Acceptable Lamp Manufacturers
1. GENERAL ELECTRIC
www.gelighting.com
2. NORTH AMERICAN PHILLIPS
www.usa.philips.com
3. SYLVANIA
www.sylvania.com

2.23 BALLASTS

A. Ballasts are for existing installations only;
1. High-efficiency;
2. NEMA Premium® Electronic fluorescent;
3. Energy Independence and Security Act (EISA) compliant;
4. No magnetic ballasts accepted;
5. Minimum 3-Year Warranty;
6. UL Listed;

B. Acceptable Ballast Manufacturers
1. PANASONIC UNIVERSAL™ LIGHTING TECHNOLOGIES
www.unvlt.com
Universal® Lighting Products;
2. PHILIPS LIGHTING ELECTRONICS
www.advance.philips.com
Philips Advance® Lighting Products

2.24 BALLASTS

A. Ballasts are for existing installations only;
1. High-efficiency;

2. NEMA Premium® Electronic fluorescent;
3. Energy Independence and Security Act (EISA) compliant;
4. No magnetic ballasts accepted;
5. Minimum 3-Year Warranty;
6. UL Listed;

B. Acceptable Emergency Ballast Manufacturers
1. PANASONIC UNIVERSAL™ LIGHTING TECHNOLOGIES
www.unvlt.com
Universal® Emergency Lighting Products;
2. PHILIPS EMERGENCY LIGHTING
www.bodine.com
Philips Bodine® Emergency Lighting Products;
Application specific;

2.25 PHOTOCELLS

A. Application dependent:
1. ½-inch Knock-out for Exterior Luminaire Control;
2. Twist-lock for Street, Highway, Parking Lot and other luminaries equipped with locking type receptacles;
3. Single-gang Junction Box Mounting for Interior/Exterior Control;
4. UL Listed;
5. 5-Year Warranty;

B. Acceptable Photocell Manufacturers
1. INVENSYS® CONTROLS PARAGON® ELECTRICAL PRODUCTS
www.paragontimecontrols.com
PARAGON®;
2. NSI INDUSTRIES LLC
www.tork.com
TORK®;

PART 3 - EXECUTION

3.1 INSTALLATION

A. Each fixture shall be a completely finished unit with all components, mounting and/or hanging devices necessary, for the proper installation of the particular fixture in its designated location and shall be completely wired ready for connection to the branch circuit wires at the outlet;
B. When fixtures are noted to be installed “flush”, they shall be complete with the proper accessories for installing in the particular ceiling involved; All flush mounted fixtures shall be supported from the structure and shall not be dependent on the hung ceiling for their support;
C. Flexible fixture hangers shall be used for all pendant mounted fixtures;
D. Receptacles shall be mounted 36-inches above the floor unless otherwise noted on the Contract Drawings;
E. Concrete poles shall be installed per Manufacturer’s instructions and as noted on the Contract Drawings;

3.2 ADJUSTING AND CLEANING

A. The luminaries shall be adjusted accordingly per Manufacturer's recommendations.
B. Clean exposed surfaces using Manufacturer recommended materials and methods.
C. Vacuum all interior spaces.

3.3 TESTING

A. Perform factory and installation tests in accordance with applicable NEC®, NEMA and UL requirements.

3.4 STARTUP SERVICES

A. Train City's maintenance personnel on procedures and schedules for energizing and de-energizing, troubleshooting, servicing and maintaining equipment and schedules.
B. Verify that all luminaries are installed and connected according to the Contract Documents.
C. Verify that wiring installation complies with requirements in Division 16 Sections.
D. Complete installation and startup checks according to Manufacturer's written instructions.

3.5 WARRANTY (PURCHASE ONLY)

A. At a minimum, Equipment Manufacturer warrants that all goods supplied are free of non-conformities in workmanship and materials for one year from date of initial operation, but not more than eighteen months from date of shipment. All standard warranties that provide additional protection shall be transferred to the City;

3.6 WARRANTY (PROJECT)

A. At a minimum, Equipment Manufacturer warrants that all goods supplied are free of non-conformities in workmanship and materials for one year from date of Substantial Completion. All standard warranties that provide additional protection shall be transferred to the City;

End of Section

Section 16670

LIGHTNING PROTECTION SYSTEM (LPS)

PART 1 - GENERAL

1.1 SCOPE

A. Provide complete lightning protection system (design, materials, labor, installation, testing, etc.) for all of the following facilities:
   1. Pumps, motors, building, light poles, antenna, fence, etc.

B. Related Work Specified Elsewhere (if included):
   1. Division 1 – General Requirements;
   2. Division 2 – Site Work;
   3. Division 3 – Concrete;
   4. Division 11 – Equipment;
   5. Division 13 – Special Construction;
   6. Division 15 – Mechanical;
   7. Division 16 – Electrical;
      a. Section 16450 - Grounding System for grounding and bonding specifics;
      b. City of Orlando, Standard details

C. The work includes, but is not limited to, furnishing and installing air terminals, grounding conductors, connectors, fasteners, ground rods and other materials necessary for a complete protective system.

D. Lightning protection system design shall comply with all applicable provisions of Lightning Protection Institute (LPI) 175 and 176, Underwriters Laboratories (UL) 96 and 96A and National Fire Protection Association® (NFPA®) 780.

1.2 REFERENCES

A. All characteristics, definitions, and terminology, except as specifically covered in this Specification, shall be in accordance with the latest revision of the following standards:
   1. Lightning Protection Institute (LPI) 175 - Installation Standard;
   2. National Electrical Contractors Association (NECA) National Electrical Installation Standards (NEIS);
   3. NECA 1 - Standard Practice of Good Workmanship in Electrical Construction;
   4. National Fire Protection Association® (NFPA®) 70 – National Electrical Code® (NEC®);
   5. NFPA® 70E® - Electrical Safety in the Workplace;
   6. NFPA® 780 – Standard for the installation of Lightning Protection Systems (latest edition);
   7. Underwriters Laboratories (UL) 96 - Safety Lightning Protection Components;
   8. UL 96A - Safety Installation Requirements for Lightning Protection Systems;

9. UL 467 - Grounding and Bonding Equipment;

1.3 SUBMITTALS

A. Submit shop drawings in accordance with the General Conditions and Section 01420.

B. All submittal documents shall be provided in both hardcopy, bounded in separate three-ring binders, indexed, tabbed with sectional dividers, and no larger than 8½-inch x 11-inch and bookmarked electronic media - Adobe® Acrobat® portable document format. Two sets of hardcopies and two sets of electronic media shall be provided.

C. All drawings shall be provided in both hardcopy, bounded, indexed, and no larger than 11-inch x 17-inch and bookmarked electronic media - Autodesk® AutoCAD® file format AND Adobe® Acrobat® portable document format. Two sets of hardcopies and two sets of electronic media shall be provided.

D. Design Drawings and plans shall be developed and provided to the Owner that describe the Lightning Protection System layout at each facility with each component and method of connection used;
   1. Descriptive bulletins;
   2. Product data sheets;
   3. Master drawing index;
   4. Dimensioned front & plan view of the assembly;
   5. Schematic diagram;
   6. Cable terminal sizes;
   7. Component list;
   8. Conduit space entry/exit locations;
   9. Ratings;
   10. Wiring diagrams;
   11. Installation information;

E. Detailed plans shall include:
   1. Down conductor;
   2. Connecting conductor;
   3. Bond strap;
   4. Air terminals;
   5. Fittings;
   6. Connectors;
   7. Ground rods;

F. Quality Control Submittals: Field test report;

G. Contract Closeout Submittals: Submit to Owner:
   1. Ground Witness Certification - Form LPI-175A;
   2. Post-Installation System Certification;
   3. UL 96 Master Label "C" Certification;

1.4 QUALITY ASSURANCE

A. Designer: Lightning protection system design shall be prepared by an LPI-certified designer or recognized Lightning Protection Manufacturer.

B. Manufacturer: All system components shall be the product of a single Manufacturer regularly engaged in the manufacturing of lightning protection components in accordance with LPI 176 and UL 96.
C. Installer: Lightning Protection System shall be installed under the direct supervision of an LPI 175 Certified Master Installer.
D. Inspector: Final installation and grounding connection inspection of the System shall be performed by the Owner representative or agent in accordance with LPI 177.
E. UL Compliance: Materials manufactured within scope of Underwriters Laboratories shall conform to UL Standards and have an applied UL Listing mark.

1.5 DELIVERY, STORAGE AND HANDLING

A. Deliver products and equipment in factory labeled packages that include recommended storage practices placed on the outside of the shipping container.
B. Handling and shipment of the products and equipment shall be in such a manner to prevent internal component damage, breakage, and denting and scoring of the enclosure finish.
C. Store and handle in strict compliance with Manufacturer's instructions and recommendations. Protect from potential damage from weather and construction operations. Store so condensation will not form on or in equipment and if necessary, apply temporary heat where required to obtain suitable service conditions.

PART 2 - PRODUCTS

2.1 GENERAL

A. Only copper components shall be used except on aluminum or galvanized steel surfaces;
B. Whenever aluminum components are used:
    1. Contractor shall provide aluminum components equivalent to the specified copper component's current carrying capability and mechanical strength, and
    2. Transition back to copper before entering the PVC down chase;
    3. No aluminum shall be allowed at or below grade;
C. The completed system(s) shall bear the UL 96 Master Label "C";
D. All material shall comply in weight, size, and composition for the class of structure to be protected as established by UL 96 and 96A.

2.2 AIR TERMINALS

A. Material: Solid copper rods, minimum 3/8-inch, with tapered points;
B. Length: Sufficient to extend minimum 10-inches above object being protected;
C. UL 96 Label B applied to each terminal;

2.3 CONDUCTORS

A. Copper Cable: Bare medium stranded, having 97.5 percent minimum conductivity;
B. Main Down Conductor: Per UL and NFPA criteria and based on building height;
C. Connecting Conductor: Secondary size per UL and NFPA criteria;
D. Bonding Conductor: Flexible strap, minimum ¾-inch wide by 1/8-inch thick;
E. All main down and connecting conductors shall bear the UL 96 Label A, applied every 10-feet;

2.4 CABLE FASTENER AND ACCESSORIES

A. Cable fasteners and accessories shall be capable of withstanding a minimum pull of 100-pounds;

2.5 FITTINGS

A. Heavy-duty Class II Bolt pressure type;
B. Bolts, Screws and Related Hardware: Type 316 Stainless steel;

2.6 GROUND RODS

A. Material: Copper clad steel ¾-inch x 20-feet long UL 467 Listed.
B. Reference Section 16450 - Grounding System for grounding and bonding specifics;

2.7 GROUNDING CONNECTIONS

A. Welds: Exothermic process;
B. Fasteners: Bolted clamp type, corrosion-resistant copper alloy;
C. Hardware: Type 316 Stainless Steel;
D. Reference Section 16450 - Grounding System for grounding and bonding specifics;

2.8 CABLE CONNECTIONS AND SPLICES

A. Welds: Exothermic process (underground).
B. Fasteners: Bolted clamp type, corrosion-resistant copper alloy (above grade).
C. Through-Roof Connectors: Straight or right angle with lead flashing washer and other appurtenances to match existing roofing system.
D. Reference Section 16450 - Grounding System for grounding and bonding specifics;

2.9 CONDUIT

A. Schedule 40 PVC, as specified in Section 16110 - Raceways, Boxes and Fittings;

2.10 ACCEPTABLE MANUFACTURERS

A. The listing of specific Manufacturers below does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed below are not relieved from meeting the specifications in their entirety. Products in compliance with the specification and

manufactured by others not named will be considered only if pre-approved by the Owner ten (10) days prior to bid date.

B. All Lightning Protection Institute (LPI) Component Manufacturers (www.lightning.org);

1. EAST COAST LIGHTNING EQUIPMENT INC.
   www.ecle.biz
   Winsted, CT
   (800) 833-3253
   (860) 379-9072
2. ERICO® PRODUCTS INC.
   www.erico.com
   Solon, OH
   (440) 248-0100
3. HARGER LIGHTNING & GROUNDING
   www.harger.com
   Grayslake, IL
   (800) 842-7437
   (847) 548-8700
4. HEARY BROS. LIGHTNING PROTECTION
   www.hearybros.com
   Springville, NY
   (800) 421-6141
   (716) 941-6141
5. INDEPENDENT PROTECTION CO., INC.
   www.ipclp.com
   Goshen, IN
   (800) 860-8388
   (574) 533-4116
6. LIGHTNING MASTERS CORP.
   www.lightningmaster.com
   Clearwater, FL
   (800) 749-6800
   (727) 447-6800
7. NATIONAL LIGHTNING PROTECTION CORP.
   www.theprotectionsource.com
   Aurora, CO
   (800) 628-2816
   (303) 295-1695
8. PREFERRED LIGHTNING PROTECTION
   www.preferredlp.com
   Maryville, MO
   (866) 299-7406
   (660) 562-2771
9. ROBBINS LIGHTNING PROTECTION INC.
   www.robbinslightning.com
   Maryville, MO
   (800) 426-3792

10. THOMPSON LIGHTNING PROTECTION, INC.
    www.tlpinc.com
    St. Paul, MN
    (800) 777-1230
    (651) 455-7661

2.11 LPS CONTRACTORS

A. Contractor shall be a Lightning Protection Institute (LPI) 175 Certified Master Installer;
B. All work shall require a UL 96 Master Label “C” upon completion and prior to acceptance.
    1. CENTRAL LIGHTNING PROTECTION INC.
       www.centrallightningprotection.com
       Orlando, FL
       (407) 380-6995
    2. MCLEAN LIGHTNING PROTECTION
       www.mcleanlp.com
       Orlando, FL
       (407) 277-9400
    3. TRIANGLE LIGHTNING PROTECTION, INC.
       no website
       Eustis, FL
       (352) 483-7020
    4. Owner Approved LPS Contractor

PART 3 - EXECUTION

3.1 INSTALLATION

A. Workmanship shall comply with all applicable provisions of LPI 175, UL 96 and 96A and NFPA® 780;
B. Installation of bare copper materials on aluminum surfaces shall not be permitted;
C. Provide waterproof seal on all roof penetrations;
D. Install system in inconspicuous manner so that components blend with building aesthetics;

3.2 EXAMINATION

A. Verify conditions prior to installation. Actual conditions may require adjustments in air terminal and ground rod locations;

3.3 AIR TERMINALS

A. Supports: Brackets or braces;
    A. Parapet Bracket Attachment: Lag or expansion bolts;
    B. Secure base to roof surface with adhesive or pitch compatible with roofing bond;
    C. Provide terminal flashing at roof penetrations;
    D. Perimeter Terminals:
        1. Maximum Spacing: 20-feet;

2. Maximum Distance from Outside Edge of Building: 2-feet;

E. Roof Ridge Terminals: Maximum spacing 20-feet;

F. Mid-Roof Terminals: Maximum spacing 50-feet;

3.4 CONDUCTORS

A. Conceal whenever practical;

B. Provide 1-inch PVC conduit in building walls or columns for main down leads and roof risers;

C. Support: Maximum spacing for exposed conductors;

1. Vertical and horizontal: 3-feet;

D. Maintain horizontal and vertical conductor courses free from dips or pockets;

E. Bends: Maximum 90 degrees, with minimum 8-inch radius;

F. Install air terminal conductors on the structural roof surface before roofing composition is applied;

G. Provide and install Bare Tinned Copper conductor for all underground wire;

3.5 BONDING

A. Bond to Main Conductor System:

1. All roof mounted ventilators, fans, air handlers, masts, flues, cooling towers, handrails and other sizeable metal objects;
2. Roof flashing, gravel stops, insulation vents, ridge vents, roof drains, soil pipe vents, and other small metal objects if located within 6 feet of main conductors or another grounded object;
3. Provide air terminals as required;

B. Bond steel columns or major framing members to grounding system per NEC®;

C. Bond each main down conductor to grounding system;

3.6 GROUNDING SYSTEM

A. Grounding Conductor:

1. Completely encircle building structure;
2. Bury minimum 30-inch below finished grade;
3. Minimum 2-feet distance from foundation walls;

B. Interconnect ground rods by direct-buried copper cables;

C. Connections:

1. Install ground cables continuous between connections;
2. Exothermic welded connections to ground rods, cable trays, structural steel, handrails, and buried and non-accessible connections;
3. Provide bolted clamp type mechanical connectors for all exposed secondary connections;
4. Use bolded offset parapet bases or through-roof concealed base assemblies for air terminal connections;
5. Provide interconnections with electrical and telephone systems and all underground water and metal pipes;
6. Provide electric service arrestor ground wire to building water main;

3.7 ADJUSTING AND CLEANING

A. Upon completion of the installation, the Contractor shall inspect and adjust accordingly per Manufacturer's recommendations.
B. Clean exposed surfaces using Manufacturer recommended materials and methods.
C. Remove any and all trash from surrounding areas and ground test well spaces.

3.8 TESTING

A. Isolate lightning protection system from other ground conditions while performing tests.
B. Resistance: Test ground resistance of grounding system by the fall-of-potential method;
    1. Test Resistance to Ground: Maximum 5 ohms;
    2. Install additional ground rods as required to obtain maximum allowable resistance;
C. Test Report:
    1. Description of equipment tested;
    2. Description of test;
    3. Test results;
    4. Conclusions and recommendations;
    5. Appendix, including appropriate test forms;
    6. Identification of test equipment used;
    7. Signature of responsible test organization authority;

3.9 STARTUP SERVICES

A. Verify that all devices are installed and connected according to the Contract Documents.
B. Verify that installation complies with requirements in Division 16 Sections.
C. Ensure UL 96 Master Label "C" Certification label is affixed to the building(s).

3.10 WARRANTY

A. Equipment Manufacturer warrants that all goods supplied are free of non-conformities in workmanship and materials for one year from date of Substantial Completion.

End of Section

Section 16709

PROTECTORS AND SURGE PROTECTION DEVICES (SPDs)

PART 1 - GENERAL

1.1 SCOPE

A. This section describes the materials and installation requirements for Protectors and Surge Protective Devices (SPDs), for the protection of all electrical, measurement, control, instrumentation and communication circuits from the effects of lightning induced currents, substation switching transients and internally generated transients resulting from inductive and/or capacitive load switching.

B. Related Work Specified Elsewhere (if included):
   1. Division 1 – General Requirements;
   2. Division 2 – Site Work;
   3. Division 3 – Concrete;
   4. Division 11 – Equipment;
   5. Division 13 – Special Construction;
   6. Division 15 – Mechanical;
   7. Division 16 – Electrical;

1.2 REFERENCES

A. All characteristics, definitions, and terminology, except as specifically covered in this Specification, shall be in accordance with the latest revision of the following standards:
   1. For Protectors – Underwriters Laboratories (UL) divides Protectors into five separate categories:
      a. Primary Protectors for Communication Circuits (QVGV);
      b. Primary Protectors for Coaxial Communications Circuits (QVKC);
      c. Protectors for Antenna Lead-in Conductors (QVLA);
      d. Secondary Protectors for Communication Circuits (QVRG);
      e. Isolated Loop Circuit Protectors for Communication Circuits (QVGQ) The primary protectors are intended for installation as defined in National Electrical Code (NEC®) Article 800. Primary coaxial protectors are intended for use on coaxial communications circuits and network-powered broadband communications systems as defined in NEC® Article 830. Protectors for antenna lead-in conductors are used to limit surges on the antenna lead-in cable that connects the antenna to the receiver/transmitter electronics. The purpose of the isolated loop circuit protector is to suppress abnormal voltages caused by hazards such as lightning and other EMI transients. An isolated loop circuit protector (ILCP) is intended for use on data or communication lines that are not exposed to accidental contact with electric light or power conductors operating at over 300V to ground. An ILCP is intended for use on Class 2 or Class 3 Remote Control, Signaling

and Power Limited Circuits or Fire Protection Signaling Circuits as defined in NEC® Articles 725 and 760 used as suppression devices for abnormal voltage conditions that may exist on the circuit due to electrical transients from an electromagnetic disturbance.

f. UL 497 - Protectors for Paired-Conductor Communications Circuits
g. UL 497A - Secondary Protectors for Communications Circuits
h. UL 497B - Protectors for Data Communications and Fire-Alarm Circuits
i. UL 497C - Protectors for Coaxial Communications Circuits
j. American National Standards Institute (ANSI) / Institute Of Electrical And Electronic Engineers (IEEE) C62.41 - Location Category A and B
k. International Electrotechnical Commission (IEC) 61643-21 - Low voltage surge protective devices – Part 21: Surge protective devices connected to telecommunications and signaling networks – Performance requirements and testing methods;

2. For SPDs - designed for repeated limiting of transient voltage surges as specified in the ANSI/UL 1449 Standard on 60-Hertz power circuits not exceeding 1000V and designated as follows:
   a. Type 1 **-** permanently connected SPDs intended for installation between the secondary of the service transformer and the line side of the service equipment overcurrent device, as well as the load side, including watt-hour meter socket enclosures and intended to be installed without an external overcurrent protective device;
   b. Type 2 **-** permanently connected SPDs intended for installation on the load side of the service equipment overcurrent device, including SPDs located at the branch panel;
   c. Type 3 **-** point of utilization SPDs, installed at a minimum of 10 meters (30 feet) from the electrical service entrance, for example cord connected, direct plug-in, receptacle type and SPDs installation the utilization equipment being protected;
   d. Type 4 **-** component SPD, including discrete components as well as component assemblies;

   The above Type SPDs have been certified by UL that the average of the transient voltage surges is limited to the Voltage Protection Rating (VPR) marked on the product. The VPR is a rating selected from a list of preferred values as given in Table 63.1 of ANSI/UL 1449 and assigned to each mode of protection. The value of the VPR is determined as the nearest highest value taken from Table 63.1 to the measured limiting voltage determined during the transient-voltage surge suppression test using the combination wave generator at a setting of 6 kV/3 kA. Mode(s) Refers to the pair of electrical connections where the VPR applies. The term "ALL" indicates that the VPR applies to all

combinations of pairs of electrical connections. UL SPD Type Testing of Type 1 and 2 SPDs are subjected to a Nominal Discharge Current test where an 8 x 20 microsecond surge current (magnitude specified by the Manufacturer) is impressed through the SPD. Type 3 SPDs are subjected to an Operating Duty Cycle test with a combination wave at 6 kV/3 kA.

e. American National Standards Institute (ANSI) / Institute of Electrical and Electronics Engineers (IEEE) C62.41.1-2002 - Surge Environment in Low-Voltage (1000 V and less) AC Power Circuits;
f. ANSI/IEEE C62.41.2-2002- Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits;
g. ANSI/IEEE C62.45-2002 - Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and Less) AC Power Circuits
h. ANSI/ Underwriters Laboratories (UL) 1449 - Surge Protective Devices, 3rd Edition;
i. National Electrical Manufacturers Association (NEMA) LS-1 - Low-Voltage Surge-Protection (LVSP) Devices;
j. National Fire Protection Association® (NFPA®) 70 – National Electrical Code® (NEC®);
k. NEC® Article 285 – Surge-Protective Devices (SPDs), 1kV or Less;
l. NFPA® 70E® - Electrical Safety in the Workplace;
m. UL 1283 - Electromagnetic Interference Filters;

1.3 SUBMITTALS

A. Submit shop drawings in accordance with the General Conditions and Section 01420.
B. All submittal documents shall be provided in both hardcopy, bounded in separate three-ring binders, indexed, tabbed with sectional dividers, and no larger than 8½-inch x 11-inch and bookmarked electronic media - Adobe® Acrobat® portable document format. Two sets of hardcopies and two sets of electronic media shall be provided.
C. All drawings shall be provided in both hardcopy, bounded, indexed, and no larger than 11-inch x 17-inch and bookmarked electronic media - Autodesk® AutoCAD® file format AND Adobe® Acrobat® portable document format. Two sets of hardcopies and two sets of electronic media shall be provided.
D. Shop Drawings shall be submitted and consist of a complete list of materials, including Manufacturer's descriptive and technical literature, catalog cuts, drawings and installation instruction;
    1. For Protectors
        a. Submit electrical/electronic product data on each protector type, including (any & all applicable)
            1) Complete part numbers and specific application reference;

2) Maximum input power;
3) Nominal impedance;
4) Nominal & Maximum line voltage;
5) Maximum line & Impulse current
6) Protection level;
7) Nominal & Maximum discharge current;
8) Clamping voltage;
9) Peak pulse current;
10) Response time;
11) Maximum shunt capacitance;
12) Maximum data rate;

b. Submit physical product data on each protector type, including –
1) Connection method;
2) Connector (in and out);
3) Grounding;
4) Housing material;
5) Dimensional drawing showing mounting arrangements;
6) Operating temperature;
7) Humidity;

c. Submit Manufacturer's certified test data for each protector type confirming a "shorted" failure mode;
d. Copy of extended warranty;

2. For SPDs
a. Submit product data on each suppressor type indicating component values including
1) Complete electrical ratings including the operating voltage rating (volts), ac power frequency (Hertz), number of phases, and load current rating (amperes);
2) VPR in volts for all modes;
3) Nominal Discharge Current (In) Rating in amps;
4) Maximum Continuous Operating Voltage Rating (MCOV) in volts;
5) Short-circuit Current Rating (SCCR) in amps;
6) I-nominal rating (I-n);
7) Complete part numbers and conductor sizes;
8) Dimensional drawing for each SPD, showing mounting arrangements;

b. Submit UL approved installation instructions in compliance with listing requirements;
c. Submit Manufacturer's certified test data for each suppressor type confirming a "shorted" failure mode;
d. Copy of extended warranty;

1.4 QUALITY ASSURANCE

A. Manufacturer shall have a minimum of ten (10) years consecutive experience producing similar electrical equipment.
B. Manufacturer shall be ISO certified.

C. UL Listing Requirements
   1. For Protectors
      a. Each Protector shall be listed per UL 497 certification to ensure comparable test evaluations and accessibility of UL's website to verify specification compliance;
      b. Each Protector shall bear the UL Mark and shall be listed to most recent editions of UL 497;
      c. "Manufactured in accordance with" is not equivalent to "UL LISTED" and does not meet the intent of this specification;
      d. Protector shall be posted at www.UL.com under Category Code: QVGV, QVKC, QVLA, QVRG or QVGQ. Products or parameters without posting at UL.com shall not be approved. To access UL Category Code QVGV, QVKC, QVLA, QVRG or QVGQ, click on Certifications in the bottom menu bar of UL's home page. Type QVGV, QVKC, QVLA, QVRG or QVGQ into the Category Code search box and click Search.
   2. For SPDs
      a. Each SPD shall be listed or recognized per ANSI/UL 1449 Third Edition certification to ensure comparable test evaluations and accessibility of UL's website to verify specification compliance;
      b. Each SPD shall bear the UL Mark and shall be listed to most recent editions of ANSI/UL 1449 and may have UL 1283 complimentary listing;
      c. "Manufactured in accordance with" is not equivalent to "UL LISTED" and does not meet the intent of this specification.
      d. SPD and performance parameters shall be posted at www.UL.com under Category Code: VZCA or VZCA2. Products or parameters without posting at UL.com shall not be approved. To access UL Category Code VZCA or VZCA2, click on Certifications in the bottom menu bar of UL's home page. Type VZCA or VZCA2 into the Category Code search box and click Search.

1.5 DELIVERY, STORAGE AND HANDLING

A. Deliver products and equipment in factory labeled packages that include recommended storage practices placed on the outside of the shipping container.
B. Handling and shipment of the products and equipment shall be in such a manner to prevent internal component damage, breakage, and denting and scoring of the enclosure finish.
C. Store and handle in strict compliance with Manufacturer's instructions and recommendations. Protect from potential damage from weather and construction operations. Store so condensation will not form on or in equipment and if necessary, apply temporary heat where required to obtain suitable service conditions.

PART 2 - PRODUCTS

2.1 CITY STANDARDIZATION

A. Approximately 90% of the City's installed Protectors & SPDs throughout the City's facilities are DEHN. The City has invested thousands of man-hours creating standards (control circuits and wiring diagrams) to facilitate the protection of field devices. The City has invested hundreds of man-hours training their personnel and thousands of dollars purchasing & stocking spare units and parts to maintain, trouble-shoot, repair and replace these Protectors & SPDs using "fully-tested" procedures and standards. The integration of another Manufacturer's product would vastly increase the integration efforts, maintenance costs and overall life-cycle costs for the City. Therefore, Protector & SPD components shall be as specified and assembled such that the intended function is achieved.

2.2 MEASUREMENT, CONTROL, INSTRUMENTATION AND FIELD BUS COMMUNICATION APPLICATIONS WITHIN AL PANEL

A. Protector shall be modular DIN rail insertion into low energy measurement, control, or communication circuits (typically twisted pair with or without a ground shield), so as to protect the components, controllers, programmable logic controllers (PLCs), remote terminal units (RTUs), and measuring instruments at either end of the circuit, against high energy transients;

B. Protector shall use a pluggable module which contains the protector circuitry, permitting the removal of this module to be accomplished without the use of tools or without interruption of the circuit due to a pair of bypass contacts;

C. Protector and base shall have been tested and passed sinusoidal & random vibration tests up to 500-Hertz and shock tests up to 30g in all three axes;

D. Protector shall be a hybrid design with a minimum of three stages, utilizing solid-state components and operating bi-directionally;

E. Protector shall meet or exceed the following criteria:

F. Provide units with a maximum single impulse current rating of 10,000 amperes (8 x 20 microseconds – current waveform) per mode;

G. Clamping (let through) voltage shall not be in excess of protected circuit volts;

H. Protector shall be replaceable without removing individual conductors or without tools (pluggable protector elements) while maintaining circuit continuity (removing the protector module shall not render the control circuit inoperable);

I. Acceptable Measurement, Control, Instrumentation and Field Bus Communication Applications Within al Panel Manufacturers

1. DEHN, INC.
   www.dehn-usa.com
   BLITZDUCTOR® SP;
   Part No. 920 300 BXT BAS;
   Part No. 926 320 BSP M4 BE 5;
   Part No. 926 322 BSP M4 BE 12;
   Part No. 926 324 BSP M4 BE 24:

Part No. 926 325 BSP M4 BE 48;
Part No. 926 326 BSP M4 BE 60;
Part No. 926 327 BSP M4 BE 180;
Part No. 926 270 BSP M2 BE HF 5;
BXT & BSP Module Base;
5V;
12V;
24V & 4-20mA;
48V;
60V;
180V;
Profibus DP;

2. NO EQUAL

2.3 IEEE 802.3 ETHERNET COMMUNICATION APPLICATIONS IN CONTROL PANELS (TYPE 2)

A. Suppressor shall be a RJ-45 Female Connector on each side for Cat 6 applications up to 48V for use in Ethernet, Gigabit Ethernet, ATM, ISDN, Voice over IP (VoIP) and Power over Ethernet (PoE) applications;
B. Suppressor shall provide surge protection of all pairs with heavy duty gas discharge tubes and a low capacitance diode matrix per pair (fully shielded universal surge arrester);
C. Suppressor shall be Din rail mount or wall mounted with supporting foot;
D. Suppressor shall meet or exceed the following criteria:
   1. Provide units with a maximum single impulse current rating of 10,000 amperes (8 x 20 microseconds – current waveform) per mode;
   2. Clamping (Let Through) voltage shall not be in excess of 48VDC;
E. Acceptable IEEE 802.3 Ethernet Communication Applications In Control Panels (Type 2) Manufacturers.
   1. DEHN, INC.
      www.dehn-usa.com
      DEHNpatch®
      Part No. 929 121 DPA M CLE RJ45B 48;
   2. NO EQUAL

2.4 COAXIAL COMMUNICATION APPLICATIONS IN CONTROL PANELS

A. Suppressor shall be a BNC Connector on each side for coaxial applications up to 8VDC for use in video, radio, Wi-Fi, Wi-Max and cable applications;
B. Suppressor shall provide surge protection of all with heavy duty gas discharge tubes and a low capacitance diode matrix (fully shielded universal surge arrester);
C. Suppressor shall be Din rail mount or wall mounted with supporting foot;
D. Suppressor shall meet or exceed the following criteria:
   1. Provide units with a maximum single impulse current rating of 10,000 amperes (8 x 20 microseconds – current waveform) per mode;
   2. Clamping (Let Through) voltage shall not be in excess of 8VDC;
E. Acceptable Coaxial Communication Applications In Control Panels Manufacturers

1. DEHN, INC.
   www.dehn-usa.com
   DEHNgate®
   Part No. 929 0XX DGA;
   XX = See catalog for specifics;
2. POLYPHASER® CORPORATION
   www.protectiongroup.com
   Broadband dc Blocked Protector,
   Part No. IS-B50HN-C2-ME Antenna surge suppression;
   Lift Stations MOTOROLA MOSCAD® Panels;
3. POLYPHASER® CORPORATION
   www.protectiongroup.com
   Broadband dc Blocked Protector,
   Part No. IS-B50NX-C1-ME Antenna surge suppression;
   Lift Stations MOTOROLA MOSCAD® ACE3600 Panels;
4. NO EQUAL

2.5 MEASUREMENT, CONTROL AND INSTRUMENTATION APPLICATIONS IN EXPOSED OUTDOOR ENVIRONMENTS

A. Suppressor shall be built within a corrosion-resistant stainless steel threaded pipe mounted in exposed outdoor environments and is attached by screwing the threaded end into the housing of the instrument it is protecting, primary application is for 24VDC, 4-20 or 0-20 mA DC loop circuits;
B. Suppressors shall be a hybrid design with a minimum of three stages, utilizing solid-state components and operating bi-directionally;
C. Suppressor shall meet or exceed the following criteria:
D. Provide units with a maximum single impulse current rating of 10,000-amperes (8 x 20 microseconds – current waveform) per mode;
E. Clamping (Let Through) voltage shall not be in excess of 36VDC;
F. Acceptable Measurement, Control and Instrumentation Applications In Exposed Outdoor Environments Manufacturers
   1. DEHN, INC.
      www.dehn-usa.com
      DEHNpipe®
      Part No. 929 921 DPI ME 24 N A2G;
   2. NO EQUAL

2.6 POWER APPLICATIONS WITHIN CONTROL PANELS, SINGLE POLE AND TWO POLE (TYPE 2)

A. Suppressor shall be DIN rail mountable;
B. Suppressor shall be MOV design with a thermal disconnect;
C. Suppressor shall have a visible status indicator;
D. Suppressor protection elements (MOV) shall be replaceable without the use of tools (i.e. pluggable);
E. Suppressor shall have unpowered Form C contacts for remote status indication;
F. Suppressor shall meet or exceed the following criteria:

1. Maximum single impulse current rating: 40,000 amperes (8 x 20 microsecond -- waveform);
2. Suppressed Voltage rating on no greater than 400VAC peak;

G. Acceptable Power Applications Within Control Panels, Single Pole (Type 2) Manufacturers
1. DEHN, INC.
www.dehn-usa.com
DEHNguard®
Part No. 952 0XX DG S XX FM;
Use in Single Line Circuit Applications Only
XX =
91 for 75V;
92 for 150V;
98 for 48V;
2. DEHN, INC.
www.dehn-usa.com
DEHNguard®
DG M TN 150 FM
Part No. 952 206
Use in 120vac Line-Neutral
Feed applications only
3. NO EQUAL

2.7 POWER APPLICATIONS WITHIN CONTROL PANELS, TWO (TYPE 3) OR FOUR POLE (TYPE 2)

A. Suppressor shall be a modular two or four DIN rail mounted device built in thermoplastic enclosure, using metal oxide and a gas discharge tube technology;
B. Suppressor shall provide for both common and differential mode protection;
C. Suppressor shall be a series device with input and output terminals (no additional terminal blocks) with built in overload protection for the MOV circuit which will disconnect without interrupting the control circuit;
D. Suppressor shall provide unpowered visual status indication;
E. Suppressor shall include a set of unpowered Form C contacts to provide a suppressor status signal to a remote location;
F. Acceptable Power Applications Within Control Panels, Two (Type 3) Or Four Pole (Type 2) Manufacturers.
1. DEHN, INC.
www.dehn-usa.com
DEHNrail®
Part No. 953 206 DR M 2P 30 FM;
Part No. 953 209 DR M 2P 150 FM;
DEHNguard®
Part No. 952 307 DG M WE 600 FM;
Part No. 952 313 DG M TNC 150 (1ø, 110/240VAC, 3-wire grounded neutral service);
24VDC Applications;

110VAC Applications;
480VAC Applications;
L3 wire to Neutral; L1 & L2 wired to the two hot wires and Ground wired to ground;
DEHN Engineered Solution DG M WE 600 ENC - Part #999-500; Size: 4.44-inch W x 7.09-inch L x 4.33-inch H; Conduit Fitting: ¾-inch watertight Meyer's hub; Enclosure: NEMA 4X; IP65; Polycarbonate, Weight: ≈ 5-lbs; $330 each;

2. NO EQUAL

2.8 SERVICE ENTRANCE MAIN DISCONNECT

A. Suppressor shall be a modular two or four DIN rail mounted device built in thermoplastic enclosure, using metal oxide and a gas discharge tube technology;
B. Suppressor shall provide for both common and differential mode protection;
C. Suppressor shall be a series device with input and output terminals (no additional terminal blocks) with built in overload protection for the MOV circuit which will disconnect without interrupting the control circuit;
D. Suppressor shall provide unpowered visual status indication; green means "Good", red means "replace module";
E. Suppressor shall include a set of unpowered Form C contacts to provide a suppressor status signal to a remote location;
F. Suppressor shall be mounted in a NEMA 4X (IP65) Enclosure per Manufacturer recommendations;
G. Acceptable Service Entrance Main Disconnect SPD Manufacturers;
   1. DEHN, INC.
      www.dehn-usa.com
      DEHNguard® modular
      Part No. 908 319, DG MU 3PY 480 3W+G R – 277/480VAC, Wye;
      Part No. 908 348, DG MU 3PH 240 4W+G R – 240VAC, Delta;
      Part No. 908 355, DG MU 3PD 480 3W+G R – 480/480VAC, Delta;
      DEHNslac NEMA 4X (IP65) Enclosure Part No. 999 995;
      For use at Lift Stations Duplex/Triplex Service Entrance Main Disconnect;
   2. NO EQUAL

2.9 SERVICE ENTRANCE SWITCHBOARDS, FRONT CONNECTED DISTRIBUTION SWITCHBOARDS, MOTOR CONTROL CENTERS, METAL-ENCLOSED SWITCHGEAR AND ALL PANELBOARDS

A. All Service Entrance Switchboards, Front Connected Distribution Switchboards, Motor Control Centers, Metal-Enclosed Switchgear and all Panelboards provided under this contract shall be protected using Type 1 or Type 2 Integral Bus Mounted SPDs;
B. SPD shall be ANSI/UL 1449 3rd Edition VZCA or VCZA2 Listed;
C. SPDs containing SCCRs using upstream overcurrent protection are prohibited;
D. SPD shall be installed internal to electrical distribution equipment by the electrical distribution equipment Manufacturer;

E. SPD shall be a self-contained module design;
F. Each suppression element shall be MOV based;
G. Each phase of the surge current diversion module shall be protected using surge rated fuses and thermal cutouts;
H. SPD shall provide surge current diversion paths between each phase conductor and the neutral conductor, between each phase conductor and the ground and between the neutral conductor and ground. For delta configured systems, the SPD shall have components connected between each phase conductor and between each phase conductor and ground.
I. SPD shall incorporate copper bus bars for the surge current path. Small gauge round wiring or plug-in connections shall not be used in the path for surge current diversion. Surge current diversion module shall be bolted directly to the bus bars of the distribution equipment for reliable low impedance connections;
J. SPD shall be equipped with on board visual and audible diagnostic monitoring. Indicator lights shall provide full time visual diagnostic monitoring of the operational status of each phase of the surge current diversion module. An amber indicator light will indicate reduced suppression capability. A red indicator light will indicate total loss of suppression capability. A green indicator light will indicate fully operational suppression capability. Audible diagnostic monitoring shall be by way of audible alarm. This alarm shall activate upon a fault condition. An alarm on/off switch shall be provided to silence the alarm. An alarm push to test switch shall be provided.
K. The SPD diagnostic monitoring device shall be mounted on the front of the panelboard, switchgear compartment, motor control center or enclosure. The diagnostic monitoring circuits shall continually monitor the operational status of the surge current diversion module. A diagnostic system press to test switch shall be provided. A set of Form C dry contacts shall be provided for remote annunciation. No other test equipment shall be required for SPD monitoring or testing before or after installation.
L. SPD shall have a response time no greater than a ½-nanosecond for any of the individual protection modes.
M. SPD shall be equipped with the following optional items:
    1. Event surge counter shall be located on the front cover of the panelboard. The counter shall be equipped with a manual reset and a battery to retain memory upon loss of AC power;
    2. Remote monitor panel with indicating lights and audible alarm for mounting in a remote location;
N. Acceptable Service Entrance Switchboards, Front Connected Distribution Switchboards, Motor Control Centers, Metal-Enclosed Switchgear and All Panelboards Manufacturers
    1. EATON CORPORATION
       www.eaton.com
       CUTLER-HAMMER® SPD Series Integrated Unit with Remote Monitor;
       SPD with Surge Counter;

2. SIEMENS INDUSTRY
www.sea.siemens.com
Sentron® Transient Protection System TPS3 with Remote Monitor; TPS3 with Surge Counter;

PART 3 - EXECUTION

3.1 INSTALLATION

A. All protectors and surge suppression devices (SPDs) shall be installed per Manufacturer's recommendations and practice.

3.2 MEASUREMENT, CONTROL, INSTRUMENTATION AND FIELD BUS COMMUNICATION APPLICATIONS WITHIN A CONTROL PANEL

A. Complete protector (base & pluggable protector module) shall be installed for all digital, analog and field bus communication conductors entering and/or leaving the control panel to provide maximum protection of the control panel or field device;

3.3 IEEE 802.3 ETHERNET COMMUNICATION APPLICATIONS IN CONTROL PANELS

A. Suppressor shall be installed for every Ethernet device, exposed to the elements such as a network camera or Wi-Fi Antenna, CAT5/6 cable network connection (media converter, switch, hub, PC, etc.) to provide maximum protection;

3.4 COAXIAL COMMUNICATION APPLICATIONS IN CONTROL PANELS

A. Suppressor shall be installed for every device, exposed to the outdoors through the use of an external antenna;

3.5 MEASUREMENT, CONTROL AND INSTRUMENTATION APPLICATIONS IN EXPOSED OUTDOOR ENVIRONMENTS

A. Suppressor shall be installed at the location of the field sensor, transmitter or device to provide maximum protection; Appropriate suppressor, based on application and device being protected, shall be used;

3.6 POWER APPLICATIONS WITHIN CONTROL PANELS, SINGLE POLE

A. Install direct-wired branch circuit suppressor at each end of the power supply conductors of each of the following devices:
   1. Fire alarm panel;
   2. Intercommunications master panel;
   3. Building management system panel;
   4. Security system panel;
   5. Power supply to the main telephone panel;
   6. Television system cable entrance, exterior antenna lead, and amplifier panel;
   7. All wall outlets which are indicated as supplying computers;
   8. Power supply to instrumentation and control system cabinets;
   9. PLCs;

10. RTUs;

3.7 POWER APPLICATIONS WITHIN CONTROL PANELS, TWO OR FOUR POLE

A. Install direct-wired branch circuit suppressor at each end of the power supply conductors of each multi-phase control panel(s);

3.8 SERVICE ENTRANCE MAIN DISCONNECT

A. Install at electrical service entrance main disconnect panel. Service entrance suppressors shall be installed on the load side of the main circuit breaker.

3.9 SERVICE ENTRANCE SWITCHBOARDS, FRONT CONNECTED DISTRIBUTION SWITCHBOARDS, MOTOR CONTROL CENTERS, METAL-ENCLOSED SWITCHGEAR AND ALL PANELBOARDS

A. Primary Service Installations
   1. Provide at each electrical service entrance and at indicated equipment. Service entrance suppressors shall be installed on the load side of the services disconnecting means and protected with a circuit breaker.
   2. Provide separate suppressor elements between each phase and ground, between each phase and neutral, and between neutral and ground, except when the suppressor is connected to service entrance equipment;
B. Secondary Service Panels
   1. Provide at each panel board, motor control center (MCC) and at indicated equipment. Install on line side of the panel and protected with a circuit breaker.
   2. Provide suppressor elements between each phase
   3. Provide suppressor element between each phase and ground, between each phase and neutral, and between neutral and ground;

3.10 ADJUSTING AND CLEANING

A. The protectors and SPDs shall be adjusted accordingly per Manufacturer's recommendations.
B. Clean exposed surfaces using Manufacturer recommended materials and methods.

3.11 TESTING

A. Perform factory and installation tests in accordance with applicable NEC®, NEMA and UL requirements.

3.12 STARTUP SERVICES

A. Engage a factory-authorized service representative to perform startup service for all SPDs.
B. Train City's maintenance personnel on procedures and schedules for energizing and de-energizing, troubleshooting, servicing and maintaining equipment and schedules.
C. Verify that all SPDs are installed and connected according to the Contract Documents;

D. D. Verify that electrical control wiring installation complies with Manufacturer's submittal by means of point-to-point continuity testing.
E. Verify that wiring installation complies with requirements in Division 16 Sections.
F. Complete installation and startup checks according to Manufacturer's written instructions.

3.13 WARRANTY

A. At a minimum, all protectors, surge suppressor devices and supporting components shall be guaranteed to be free of defects in materials and workmanship for a minimum of five (5) years from the date of Substantial Completion. Protectors, SPDs or components damaged prior to Substantial Completion shall be replaced at no cost to the City.

End of Section

Section 16903

REMOVAL OF EXISTING EQUIPMENT

PART 1 - GENERAL

1.1 SCOPE

A. This section describes the requirements for removal, disposal and transfer of existing equipment.

B. Related Work Specified Elsewhere (if included):

1. Division 1 – General Requirements;
2. Division 2 – Site Work;
3. Division 3 – Concrete;
4. Division 11 – Equipment;
5. Division 13 – Special Construction;
6. Division 15 – Mechanical;
7. Division 16 – Electrical;

1.2 REFERENCES

A. All characteristics, definitions, and terminology, except as specifically covered in this Specification, shall be in accordance with the latest revision of the following standards:

1. National Fire Protection Association® (NFPA®) 70 – National Electrical Code® (NEC®);
2. NFPA® 70E® - Electrical Safety in the Workplace;

1.3 SUBMITTALS

A. Submit shop drawings in accordance with the General Conditions and Section 01420.

B. All submittal documents shall be provided in both hardcopy, bounded in separate three-ring binders, indexed, tabbed with sectional dividers, and no larger than 8½-inch x 11-inch and bookmarked electronic media - Adobe® Acrobat® portable document format. Two sets of hardcopies and two sets of electronic media shall be provided.

C. All drawings shall be provided in both hardcopy, bounded, indexed, and no larger than 11-inch x 17-inch and bookmarked electronic media - Autodesk® AutoCAD® file format AND Adobe® Acrobat® portable document format. Two sets of hardcopies and two sets of electronic media shall be provided.

D. A list of all equipment to be delivered to the City shall be provided prior to Substantial Completion. All other equipment and/or materials shall be disposed of by the Contractor without additional costs to the City;

1.4 QUALITY ASSURANCE (NOT USED)

1.5 DELIVERY, STORAGE AND HANDLING (NOT USED)

PART 2 - PRODUCTS

2.1 SALVAGEABLE EQUIPMENT AND MATERIALS

A. All equipment and materials which are removed through modifications and demolition shall remain the property of the City.
B. Carefully remove any salvageable equipment and materials from the site and suitably place as directed by the City.
C. The City may include a list of materials and/or equipment that shall modify this requirement.

PART 3 - EXECUTION (NOT USED)

End of Section

Section 16950

ELECTRICAL TESTING (TOOLS & TRAINING)

PART 1 - GENERAL

1.1 SCOPE

A. This section describes the minimum testing and documentation requirements that shall be performed, documented, certified and provided to the Engineer and City for acceptance of the electrical wiring, equipment and installation as shown on the Contract Drawings and specified herein.

B. Related Work Specified Elsewhere (if included):
   1. Division 1 – General Requirements
   2. Division 2 – Site Work
   3. Division 3 – Concrete
   4. Division 11 – Equipment
   5. Division 13 – Special Construction
   6. Division 15 – Mechanical
   7. Division 16 – Electrical

1.2 REFERENCES

A. All characteristics, definitions, and terminology, except as specifically covered in this Specification, shall be in accordance with the latest revision of the following standards.
   1. American National Standards Institute (ANSI) 450 Recommended Practice for Maintenance, Testing, and Replacement of Large lead Storage Batteries for Generator Stations and Substations.
   2. ANSI C2 - National Electrical Safety Code.
   3. ANSI C37.20.1 - Metal-Enclosed Low Voltage Power Circuit Breaker Switchgear.
   4. ANSI C37.20.2 - Metal-Clad and Station-Type Cubicle Switchgear.
   5. ANSI C37.20.3 - Metal-Enclosed Interrupter Switchgear.
   6. ANSI C62.33 - Standard Test Specifications for Varistor Surge-Protective Devices.
   7. American Society for Testing and Materials (ASTM) D665 - Standard Test Method for Rust Preventing Characteristics of Inhibited Mineral Oil in the Presence of Water.
   8. ASTM DS77 - Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes.
   9. ASTM D923 - Standard Test Method for Sampling Electrical Insulating Liquids.
   10. ASTM D924 - Standard Test Methods for A-Class Characteristics and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids.
   11. ASTM D971 - Standard Test Method for Interfacial Tension of 0.1 Against Water by the Ring Method.

12. ASTM D974 - Standard Test Method for Acid and Base Number by Color-Indicator Titration.
13. ASTM D1298 - Standard Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method.
14. ASTM D1500 - Standard Test Method for ASTM Color of Petroleum Products.
15. ASTM D1524 - Standard Test Method for Visual Examination of Used Electrical Insulating Oils of Petroleum Origin in the Field.
16. ASTM D1533 - Standard Test Methods for Water in Insulating Liquids.
17. ASTM D1816 - Standard Test Method for Dielectric Breakdown Voltage of Insulating Oils of Petroleum Origin Using VDE Electrodes.
18. ASTM D2285 - Standard Test Method for Interfacial Tension of Electrical Insulating Oils of Petroleum Origin Against Water by the Drop- Weight Method.
19. Institute of Electrical and Electronics Engineers (IEEE) 43 - Recommended Practice for Testing Insulating Resistance of Rotating Machinery.
20. IEEE 48 - Standard Test Procedures and Requirements for High-Voltage Alternating-Current Cable Terminators.
21. IEEE 81 - Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System.
22. IEEE 95 - Recommended Practice for Insulation Testing of Large AC Rotating Machinery with High Direct Voltage.
23. IEEE 118 - Standard Test Code for Resistance Measurement.
24. IEEE 400 - Guide for Making High-Direct-Voltage Tests on Power Cable Systems in the Field.
25. National Electrical Manufacturers Association (NEMA) AB 4 Guideline for Inspection and Preventive Maintenance of Molded Case Circuit Breakers Used in Commercial and Industrial Applications.
26. National Fire Protection Association (NFPA) 70 – National Electric Code (NEC®).
27. NEMA PB 2 - Dead-front Distribution Switchboards.
28. NEMA WC 7 - Cross-Linked-Thermosetting-Polyethylene-Wire and Cable for the Transmission and Distribution of Electrical Energy.
29. NEMA WC 8 - Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
30. International Electrical Testing Association (NETA) ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.
31. NFPA 70E® - Electrical Safety in the Workplace.

1.3 SUBMITTALS

A. Submit shop drawings in accordance with the General Conditions and Section 01420.

B. All submittal documents shall be provided in both hardcopy, bounded in separate three-ring binders, indexed, tabbed with sectional dividers, and no larger than 8½-inch x 11-inch and bookmarked electronic media - Adobe®

Acrobat® portable document format. Two sets of hardcopy and two sets of electronic media shall be provided.

C. All drawings shall be provided in both hardcopy, bounded, indexed, and no larger than 11-inch x 17-inch and bookmarked electronic media - Autodesk® AutoCAD® file format AND Adobe® Acrobat® portable document format. Two sets of hardcopy and two sets of electronic media shall be provided.

D. Administrative Submittals: Submit 30 days prior to performing inspections or tests:
   1. Schedule for performing inspection and tests.
   2. List of references to be used for each test.
   3. Sample copy of equipment and materials inspection form(s).
   4. Sample copy of individual device test form.
   5. Sample copy of individual system test for.

E. Quality Control Submittals: Submit within 30 days after completion of test:
   1. Test or inspection reports and certificates for each electrical item tested.

F. Contract Closeout Submittals:
   1. Operation and Maintenance Data:
      a. In accordance with Section 01730 Operation and Maintenance Data.
      b. After test or inspection reports and certificates have been reviewed by Engineer and returned, insert a copy of each in operation and maintenance manual.

1.4 QUALITY ASSURANCE

A. Testing Firm Qualifications:
   1. Corporately and financially independent organization functioning as an unbiased testing authority
   2. Professionally independent of Manufacturers, suppliers, and installers, of electrical equipment and systems being tested
   3. Employer of engineers and technicians regularly engaged in testing and inspecting of electrical equipment, installations, and systems
   4. Supervising engineer accredited as Certified Electrical Test Technologist by National Institute for Certification of Engineering Technologists (NICET), or International Electrical Testing Association and having a minimum of 5 years testing experience on similar projects
   5. Technicians certified by NICET or NETA
   6. Assistants and apprentices assigned to project at ratio not to exceed two certified to one non-certified assistant or apprentice
   7. Registered Professional Engineer to provide comprehensive project report outlining services performed, results of such services, recommendations, actions taken and opinions
   8. In compliance with OSHA Title 29, Part 1907 criteria for accreditation of testing laboratories or a full Member Company of International Electrical Testing Association

B. Test equipment shall have an operating accuracy equal to, or greater than, requirements established by NETA ATS.

C. Test instrument calibration shall be in accordance with NETA ATS.

1.5 DELIVERY, STORAGE AND HANDLING

A. Deliver products and equipment in factory labeled packages that include recommended storage practices placed on the outside of the shipping container.
B. Handling and shipment of the products and equipment shall be in such a manner to prevent internal component damage, breakage, and denting and scoring of the enclosure finish.
C. Store and handle in strict compliance with Manufacturer's instructions and recommendations. Protect from potential damage from weather and construction operations. Store so condensation will not form on or in equipment and if necessary, apply temporary heat where required to obtain suitable service conditions.

1.6 SEQUENCING AND SCHEDULING

A. Perform inspection and electrical tests after equipment has been installed.
B. Perform tests with apparatus de-energized whenever feasible.
C. Inspection and electrical tests on energized equipment are to be:
    1. Scheduled with Engineer prior to de-energization
    2. Minimized to avoid extended period of interruption to the operating plant Equipment
D. Notify Engineer at least 24 hours prior to performing tests on energized electrical equipment.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 GENERAL

A. Tests specified in this section are to be performed in accordance with the requirements of Section 01650 Facility Startup/Checkout.
B. Tests and inspection shall establish that:
    1. Electrical equipment is operational within industry and Manufacturer's tolerances
    2. Installation operates properly
    3. Equipment is suitable for energization
    4. Installation conforms to requirements of Contract Documents and NFPA 70, NFPA 70E and ANSI C2
C. Perform inspection and testing in accordance with NETA ATS, industry standards and Manufacturer's recommendations.
D. Set, test, and calibrate protective relays, circuit breakers, fuses and other applicable devices in accordance with values established by the short circuit and coordination study as specified in Section 16015 Electrical Systems Analysis
E. Adjust mechanisms and moving parts for free mechanical movement
F. Adjust adjustable relays and sensors to correspond to operating conditions, or as recommended by Manufacturer

G. Verify nameplate data for conformance to Contract Documents
H. Realign equipment not properly aligned and correct any unevenness
I. Properly anchor electrical equipment found to be inadequately anchored
J. Tighten accessible bolted connections, including wiring connections, with calibrated torque wrench to Manufacturer's recommendations, or as otherwise specified
K. Clean contaminated surfaces with cleaning solvents as recommended by Manufacturer
L. Provide proper lubrication of applicable moving parts
M. Inform Engineer of working clearances not in accordance with NEC®
N. Investigate and repair or replace:
    1. Electrical items that fail tests
    2. Active components not operating in accordance with Manufacturer's instructions
    3. Damaged electrical equipment
O. Electrical Enclosures:
    1. Remove foreign material and moisture from enclosure interior
    2. Vacuum and wipe clean enclosure interior
    3. Remove corrosion found on metal surfaces
    4. Repair or replace, as determined by Engineer, door and panel sections having dented surfaces
    5. Repair or replace, as determined by Engineer, poor fitting doors and panel sections
    6. Repair or replace improperly operating latching, locking, or interlocking devices
    7. Replace missing or damaged hardware
    8. Finish:
        a. Provide matching paint and touch up scratches and marks
        b. If required due to extensive damage, as determined by Engineer, refinish the entire assembly
P. Replace fuses and circuit breakers that do not conform to size and type required by the Contract Documents.
Q. Replace transformer insulating oil not in compliance with ASTM D923.

3.2 SWITCHGEAR AND SWITCHBOARD ASSEMBLIES

A. Visual and Mechanical Inspection:
    1. Insulator damage and contaminated surfaces.
    2. Proper barrier and shutter installation and operation.
    3. Proper operation of indicating devices.
    4. Improper blockage of air-cooling passages.
    5. Proper operation of draw-out elements.
    6. Integrity and contamination of bus insulation system.
    7. Check Door and Device Interlocking System By:
        a. Closure attempt of device when door is in OFF or OPEN position.
        b. Opening attempt of door when device is in ON or CLOSED position.
    8. Check Key Interlocking Systems For:
        a. Key captivity when device is in ON or CLOSED position.

b. Key removal when device is in ON or CLOSED position.
c. Closure attempt of device when key has been removed.
d. The correct number of keys in relationship to number of lock cylinders;
e. Existence of other keys capable of operating lock cylinders (Destroy duplicate sets of keys);

9. Check Nameplates for Proper Identification Of:
   a. Equipment title and tag number with latest one-line diagram.
   b. Pushbutton.
   c. Control switch.
   d. Pilot light.
   e. Control relay.
   f. Circuit breaker.
   g. Indicating meter.
10. Verify that fuse and circuit breaker ratings, sizes, and types conform to those specified,
11. Check bus and cable connections for high resistance by low resistance ohmmeter and calibrated torque wrench thermographic survey applied to bolted joints.
    a. Ohmic value to be zero;
    b. Bolt torque level in accordance with NETA ATS, Table 10. 1, unless otherwise specified by Manufacturer;
    c. Thermographic survey temperature gradient of 2° C or less;
12. Check Operation and Sequencing of Electrical and Mechanical Interlock Systems By:
    a. Closure attempt for locked open devices.
    b. Opening attempt for locked closed devices.
    c. Key exchange to operate devices in OFF-NORMAL positions.
13. Verify performance of each control device and feature.
14. Control Wiring:
    a. Compare wiring to local and remote control and protective devices with elementary diagrams.
    b. Proper conductor lacing and bundling.
    c. Proper conductor identification.
    d. Proper conductor logs and connections.
15. Exercise active components.
16. Perform phasing check on double-ended equipment to ensure proper bus phasing from each source.

B. Electrical Tests:
1. Insulation Resistance Tests:
   a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 7.1.1.
   b. Each phase of each bus section.
   c. Phase-to-phase and phase-to-ground for 1 minute.
   d. With switches and breakers open.
   e. With switches and breakers closed.
   f. Control wiring except that connected to solid-state components.

g. Insulation resistance values equal to, or greater than, Ohmic values established by Manufacturer.

2. Overpotential Tests:
   a. Applied ac or dc voltage and test procedure in accordance with ANSI C37.20.3 and NEMA PB 2.
   b. Each phase of each bus section.
   c. Phase-to-phase and phase-to-ground for 1 minute.
   d. Test results evaluated on a pass/fail basis.
   e. Current Injection Tests:
   f. For entire current circuit in each section.
   g. Secondary injection for current flow of 1 ampere.
   h. Test current at each device.
3. Control Wiring:
   a. Apply secondary voltage to control power and potential circuits.
   b. Check voltage levels at each point on terminal boards and each device terminal.
4. Operational Test:
   a. Initiate control devices.
   b. Check proper operation of control system in each section.

3.3 DRY TYPE TRANSFORMERS

A. Visual and Mechanical Inspection:
   1. Physical and insulator damage.
   2. Proper winding connections.
   3. Bolt torque level in accordance with NETA ATS, Table 10.1, unless otherwise specified by Manufacturer.
   4. Defective wiring.
   5. Proper operation of fans, indicators, and auxiliary devices.
   6. Removal of shipping brackets, fixtures, or bracing.
   7. Free and properly installed resilient mounts.
   8. Cleanliness and improper blockage of ventilation passages.
   9. Verify that tap-changer is set at correct ratio for rated output voltage under normal operating conditions.
   10. Verify proper secondary voltage phase-to-phase and phase-to-ground after energization and prior to loading.

B. Electrical Tests:
   1. Insulation Resistance Tests:
      a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 7.2.3 for each Winding-to-winding and Winding-to-ground;
      b. Ten-minute test duration with resistances tabulated at 30 seconds, 1 minute and 10 minutes.
      c. Results temperature corrected in accordance with NETA ATS, Table 7.2.4.
      d. Temperature corrected insulation resistance values equal to, or greater than, Ohmic values established by Manufacturer.
      e. Insulation resistance test results to compare within 1 percent of adjacent windings.

2. Perform tests and adjustments for fans, controls, and alarm functions as suggested by Manufacturer.

3.4 LOW VOLTAGE CABLES, 600-VOLTS MAXIMUM

A. Visual and Mechanical Inspection:
   1. Inspect Each Individual Exposed Power Cable No. 6 and Larger For:
      a. Physical damage.
      b. Proper connections in accordance with single-line diagram.
      c. Cable bends not in conformance with Manufacturer's minimum allowable bending radius where applicable.
      d. Color coding conformance with specifications.
      e. Proper circuit identification.
   2. Mechanical Connections For:
      a. Proper lug type for conductor material.
      b. Proper lug installation.
      c. Bolt torque level in accordance with NETA ATS, Table 10. 1, unless otherwise specified by Manufacturer.
   3. Shielded Instrumentation Cables For:
      a. Proper shield grounding.
      b. Proper terminations.
      c. Proper circuit identification.
   4. Control Cables For:
      a. Proper termination.
      b. Proper circuit identification.
   5. Cables Terminated Through Window Type CTs: Verify that neutrals and grounds are terminated for correct operation of protective devices.

B. Electrical Tests for Conductors No. 6 and Larger:
   1. Insulation Resistance Tests:
      a. Test each conductor with respect to ground and to adjacent conductors per IEEE 118 procedures for 1 minute.
      b. Evaluate Ohmic values by comparison with conductors of same length and type.
      c. Investigate values less than 50 megohms.
      d. Utilize 1,000V dc megohmmeter for 600V insulated conductors.
   2. Continuity test by ohmmeter method to ensure proper cable connections.

3.5 SAFETY SWITCHES, 600-VOLTS MAXIMUM

A. Visual and Mechanical Inspection:
   1. Proper blade pressure and alignment.
   2. Proper operation of switch operating handle.
   3. Adequate mechanical support for each fuse.
   4. Proper contact-to-contact tightness between fuse clip and fuse.
   5. Cable connection bolt torque level in accordance with NETA ATS, Table 10.1.
   6. Proper phase barrier material and installation.
   7. Verify that fuse sizes and types correspond to one-line diagram.

8. Perform mechanical operational test and verify electrical and mechanical interlocking system operation and sequencing.

B. Electrical Tests:
   1. Insulation Resistance Tests:
      a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 10.2.
      b. Phase-to-phase and phase-to-ground for 1 minute on each pole.
      c. Insulation resistance values equal to, or greater than, Ohmic values established by Manufacturer.
   2. Contact Resistance Tests:
      a. Contact resistance in micro-ohms across each switchblade and fuse holder.
      b. Investigate deviation of 50 percent or more from adjacent poles or similar switches.

3.6 MOLDED AND INSULATED CASE CIRCUIT BREAKERS

A. General: Inspection and testing limited to circuit breakers rated ≥70 amperes and to motor circuit protector breakers rated ≥50 amperes.

B. Visual and Mechanical Inspection:
   1. Proper mounting.
   2. Proper conductor size.
   3. Feeder designation according to nameplate and one-line diagram.
   4. Cracked casings.
   5. Connection bolt torque level in accordance with NETA ATS, Table 10.1.
   6. Operate breaker to verify smooth operation.
   7. Compare frame size and trip setting with circuit breaker schedules or one-line diagram.
   8. Verify that terminals are suitable for 75 °C rated insulated conductors.

C. Electrical Tests:
   1. Insulation Resistance Tests:
      a. Utilize 1,000-volt dc megohmmeter for 480- and 600-volt circuit breakers and 500-volt dc megohmmeter for 240-volt circuit breakers.
      b. Pole-to-pole and pole-to-ground with breaker contacts opened for 1 minute.
      c. Pole-to-pole and pole-to-ground with breaker contacts closed for 1 minute.
      d. Test values to comply with NETA ATS, Table 10.2.
   2. Contact Resistance Tests:
      a. Contact resistance in micro-ohms across each pole.
      b. Investigate deviation of 50 percent or more from adjacent poles and similar breakers.
   3. Primary Current Injection Test to Verify:
      a. Long-time minimum pickup and delay.
      b. Short-time pickup and delay.
      c. Ground fault pickup and delay.
      d. Instantaneous pickup by run-up or pulse method.

e. Trip characteristics of adjustable trip breakers shall be within Manufacturer's published time-current characteristic tolerance band, including adjustment factors.
f. Trip times shall be within limits established by NEMA AB 4, Table 5-3.
g. Instantaneous pickup value shall be within values established by NEMA AB 4, Table 5-4.

3.7 INSTRUMENT TRANSFORMERS

A. Visual and Mechanical Inspection:
1. Visually Check Current, Potential, and Control Transformers For:
a. Cracked insulation.
b. Broken leads or defective wiring.
c. Proper connections.
d. Adequate clearances between primary and secondary circuit wiring.
2. Verify Mechanically That:
a. Grounding and shorting connections have good contact.
b. Withdrawal mechanism and grounding operation, when applicable, operate properly.
3. Verify proper primary and secondary fuse sizes for potential transformers.

B. Electrical Tests:
1. Current Transformer Tests:
a. Insulation resistance test of transformer and wiring-to-ground at 1,000-Volts dc for 30 seconds.
b. Polarity test.
2. Potential Transformer Tests:
a. Insulation resistance test at test voltages in accordance with NETA ATS, Table 7.1.1 for 1 minute on Winding-to-winding and Winding-to-ground.
b. Polarity test to verify polarity marks or H1-X1 relationship as applicable.
3. Insulation resistance measurement on instrument transformer shall not be less than that shown in NETA ATS, Table 7.1.1.

3.8 METERING

A. Visual and Mechanical Inspection:
1. Verify meter connections in accordance with appropriate diagrams.
2. Verify meter multipliers.
3. Verify that meter types and scales conform to Contract Documents.
4. Check calibration of meters at cardinal points.
5. Check calibration of electrical transducers.

3.9 GROUNDING SYSTEMS

A. Visual and Mechanical Inspection:
   1. Equipment and circuit grounds in motor control centers, panelboards, switchboards, and switchgear assemblies for proper connection and tightness.
   2. Ground bus connections in motor control centers, panelboards, switchboards, and switchgear assemblies for proper termination and tightness,
   3. Effective transformer core and equipment grounding.
   4. Accessible connections to grounding electrodes for proper fit and tightness.
   5. Accessible exothermic-weld grounding connections to verify that molds were fully filled and proper bonding was obtained.

B. Electrical Tests:
   1. Fall-Of-Potential Test:
      a. In accordance with IEEE 81, Section 8.2.1.5 for measurement of main ground system's resistance.
      b. Main ground electrode system resistance to ground to be no greater than 5 ohms.
   2. Two-Point Direct Method Test:
      a. In accordance with IEEE 81, Section 8.2. 1.1, for measurement of ground resistance between main ground system, equipment frames, and system neutral and derived neutral points.
      b. Equipment ground resistance shall not exceed main ground system resistance by 0.50 ohm.

3.10 GROUND FAULT SYSTEMS

A. Inspection and Testing Limited To:
   1. Zero sequence grounding systems.
   2. Residual ground fault systems.

B. Visual and Manual Inspection:
   1. Neutral Main Bonding Connection to Assure:
      a. Zero sequence sensing system is grounded ahead of neutral disconnect link.
      b. Ground strap sensing system is grounded through sensing device.
      c. Neutral ground conductor is solidly grounded.
   2. Verify that control power has adequate capacity for system.
   3. Manually Operate Monitor Panels For:
      a. Trip test.
      b. No trip test.
      c. Non-automatic rest.
   4. Zero sequence system for symmetrical alignment of core balance transformers about current carrying conductors.
   5. Relay check for pickup and time under simulated ground fault conditions.
   6. Verify nameplate identification by device operation.

C. Electrical Tests:
1. Test system neutral insulation resistance with neutral ground link removed. System neutral insulation resistance minimum 1 mega-ohm.
2. Determine relay pickup by primary current injection at the sensor. Relay pickup current within plus or minus 10 percent of device dial or fixed setting.
3. Test relay timing by injecting 300 percent of pickup current, or as specified by Manufacturer. Relay operating time in accordance with Manufacturer's time-current characteristic curves.
4. Test system operation at 55 percent rated control voltage, if applicable.
5. Test zone interlock system by simultaneous sensor current injection and monitoring zone blocking functions.

3.11 AC INDUCTION MOTORS

A. General: Inspection and testing limited to motors rated 5 horsepower and larger.
B. Visual and Mechanical Inspection:
1. Proper electrical and grounding connections.
2. Shaft alignment.
3. Blockage of ventilating air passageways.
4. Operate Motor and Check For:
a. Excessive mechanical and electrical noise.
b. Overheating.
c. Correct rotation.
d. Check vibration detectors, resistance temperature detectors, or motor inherent protectors for functionality and proper operation.
e. Excessive vibration.
5. Check operation of space heaters.
C. Electrical Tests:
1. Insulation Resistance Tests:
a. In accordance with IEEE 43 at test voltages established by NETA ATS, Table 10.2 for:
1) Motors above 200 horsepower for l0-minute duration with resistances tabulated at 30 seconds, 1 minute, and 10 minutes.
2) Motors 200 horsepower and less for 1-minute duration with resistances tabulated at 30 and 60 seconds.
b. Insulation resistance values equal to, or greater than, ohmic values established by Manufacturers.
2. Calculate polarization index ratios for motors above 200 horsepower. Investigate index ratios less than 1.5 for Class A insulation and 2.0 for Class B insulation.
3. Insulation resistance test on insulated bearings in accordance with Manufacturer's instructions.
4. Measure running current and voltage and evaluate relative to load conditions and nameplate full-load amperes.
5. Overpotential Tests:
a. Applied dc voltage in accordance with IEEE 95.

b. Limited to 4,000-volt motors rated 1,000 horsepower and greater.
c. Test results evaluated on pass/fail basis.

3.12 THERMOGRAPHIC SURVEY

A. Provide a thermographic survey of connections associated with incoming service conductors, bus work, and branch feeder conductors No. 2 and larger at each:
   1. Medium voltage switchgear and transformer
   2. Switchboard
   3. Low voltage motor control center
   4. Panelboard
B. Provide a thermographic survey of feeder conductors No. 2 and larger terminating at:
   1. Motors rated 30 horsepower and larger
   2. Medium and low voltage disconnect switches
   3. Transfer switches
   4. Engine-generators
C. Remove necessary enclosure metal panels and covers prior to performing survey.
D. Perform with equipment energized during periods of maximum possible loading.
E. Do not perform survey on equipment operating at less than 20 percent of rated connected operating load.
F. Utilize Thermographic Equipment Capable Of:
   1. Detecting emitted radiation
   2. Converting detected radiation to visual signal
   3. Detecting 1 °C temperature difference between subject area and reference point of 30 °C
G. Temperature Gradients Of:
   1. 3 °C to 7 °C indicates possible deficiency that warrants investigation.
   2. 7 °C to 15 °C indicates deficiency that is to be corrected as time permits.
   3. 16 °C and above indicates deficiency that is to be corrected immediately.
H. Provide Written Report Of:
   1. Areas surveyed and the resultant temperature gradients.
   2. Locations of areas having temperature gradients of 3 °C or greater.
   3. Cause of heat rise and actions taken to correct the cause of heat rise.
   4. Detected phase unbalance.

End of Section

APPENDIX "A"

CTY OF ORLANDO LOW VOLTAGE STANDARDS