

SECTION 16000

BASIC ELECTRICAL REQUIREMENTS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

- A. The CONTRACTOR shall furnish all labor, materials, tools, and equipment, and perform all work and services necessary for, or incidental, to the furnishing and installation of all electrical work as shown on the Drawings, and as specified in accordance with the provisions of the Contract Documents and completely coordinate with the work of other trades involved in the general construction. Although such work is not specifically shown or specified, all supplementary or miscellaneous items, appurtenances, and devices incidental to or necessary for a sound, secure, and complete installation shall be furnished and installed as part of this work. The CONTRACTOR shall obtain approved Shop Drawings showing wiring diagrams, connection diagrams, roughing-in and hook up details for all equipment and comply therewith. All electrical work shall be complete and left in operating condition in accordance with the intent of the Drawings and the Specifications for the electrical work.
- B. Where the word "CONTRACTOR" appears in these Technical Specifications it shall be construed to mean the Electrical Contractor.
- C. The scope of work for this project primarily includes, but is not limited to, the following:
 - 1. Demolition of control and instrumentation circuits.
 - 2. Install new control and instrumentation wiring.
 - 3. Install junction boxes and connect replaced exhaust fan power wiring to existing MCC.
 - 4. Install wiring for temporary blower.
 - 5. Install grounding for replaced equipment.
 - 6. Other electrical work as specified herein and on the drawings.
- D. All electrical equipment shall conform to the applicable NEMA specifications. All electrical equipment shall be properly identified in accordance with these Specifications and Contract Drawings. Nameplates shall be engraved high pressure plastic laminate, black with white lettering for 120/208 or 120/240V equipment, and red with white lettering for 277/480 or 480V equipment. The nameplates shall be attached to the equipment cabinets with two (2) stainless steel sheet metal screws for nameplates up to 2-inch wide. For nameplates over 2-inch wide, four (4) stainless steel sheet metal screws shall be used, one (1) in each corner of the nameplate. All panelboards, starters, control panels, cabinet enclosures, and equipment switches shall be labeled in the manner described, or in an equally approved manner.

- E. All materials, equipment, sizes and capacities of electrical equipment incorporated in the project shall conform to the latest requirements of the current National Electric Code, the National Electrical Manufacturer's Association, the State and local electrical codes, and to applicable rules and regulations of the local electrical utility serving the project.
- F. All material and equipment must be the product of an established and reputable manufacturer; must be new and of first class construction; must be designed and guaranteed to perform the service required; and must bear the label of approval of the Underwriters Laboratories, Inc., where such approval is available for the product of the listed manufacturer as approved by the ENGINEER.
- G. When a specified or indicated item has been superseded or is no longer available, the manufacturer's latest equivalent type or model of material or equipment as approved by the ENGINEER shall be furnished and installed at no additional cost to the OWNER.
- H. Where the CONTRACTOR's selection of equipment of specified manufacturers or additionally approved manufacturers requires changes or additions to the system design, the CONTRACTOR shall be responsible in all respects for the modifications to all system designs, subject to approval of the ENGINEER. The CONTRACTOR's bid shall include all costs for all work of the Contract for all trades made necessary by such changes, additions or modifications or resulting from any approved substitution.
- I. Furnish and install all stands, racks, brackets, supports, and similar equipment required to properly serve the equipment which is furnished under this Contract, or equipment otherwise specified or indicated on the Drawings.

1.02 DRAWINGS

- A. Conduits and wiring are shown diagrammatically only, and the layout does not necessarily show the total number of conduits for the circuits required, nor are the locations of indicated runs intended to show the actual routing of conduits. The CONTRACTOR shall furnish, install, and place in satisfactory condition ready for operation, all conduits, cables, and all other material needed for the complete lighting, power, and other electrical systems shown or indicated in the Contract Documents. Additional conduits and the required wiring shall be installed by the CONTRACTOR for wherever needed to complete the installation of the specific equipment furnished, at no additional cost to the OWNER.

1.03 EQUIPMENT LOCATION

- A. The Drawings show the general location of feeders, transformers, outlets, conduits, and circuit arrangements. Because of the small scale of the Drawings, it is not possible to indicate all of the details involved. The CONTRACTOR shall carefully investigate the structural and finish conditions affecting all of his work and shall arrange such work accordingly; furnishing such fittings, junction boxes, and accessories as may be required to meet such conditions. The CONTRACTOR shall refer to the entire Drawing set to verify openings, special surfaces, and location of other equipment, or other special equipment prior to roughing-in for panels, switches, and other outlets. The CONTRACTOR shall verify all equipment dimensions to insure that proposed equipment will fit properly in spaces indicated.

1.04 LOCAL CONDITIONS

- A. The CONTRACTOR shall examine the site and become familiar with conditions affecting the work. He shall investigate, determine, and verify locations of any overhead or buried utilities on or near the site, and shall determine such locations in conjunction with all public and/or private utility companies and with all authorities having jurisdiction. All costs, both temporary and permanent to connect all utilities, shall be included in the Bid. The CONTRACTOR shall be responsible for scheduling and coordinating with the local utility for temporary and permanent services.

1.05 SUBMITTALS

- A. The CONTRACTOR shall submit to the ENGINEER Shop Drawings of all electrical materials, apparatus, appliances, equipment and miscellaneous devices shown or specified and shall be in accordance with the requirements of the General Conditions and Section 01300, Submittals.
- B. Shop Drawings shall be sufficiently complete in detail to enable the ENGINEER to determine compliance with Contract requirements. Details and information shown shall include but are not necessarily limited to the following:
 - 1. Performance characteristics.
 - 2. Physical sizes.
 - 3. Material and equipment specifications, and construction and methods of fabrication details.
 - 4. Compliance with standards (e.g. UL, NEMA), rules, regulations, and codes.
 - 5. Accessories.
 - 6. Complete wiring diagrams showing circuit designations as shown on the Drawings. A complete wiring diagram shall be submitted for each controller furnished.
 - 7. Complete product data sheets for all components of the specified equipment.
 - 8. Electrical ratings (voltage, current, KVA, phase, etc.)
 - 9. Weights of components parts and assembled unit weights.
 - 10. Complete assembly, layout, and installation drawings with clearly marked dimensions.
- C. Partial, incomplete or illegible submittals will be returned to the CONTRACTOR without review for resubmittal.
- D. Shop Drawings will be approved only to the extent of the information shown. Approval of an item of equipment shall not be construed to mean approval for components of that item for which CONTRACTOR has provided no information.

- E. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's specification section.
- F. Each submittal shall be identified by the applicable specification section.

1.06 APPLICABLE CODES AND REQUIREMENTS

A. Conformance

1. All work, equipment and materials furnished shall conform with the existing rules, requirements and specifications of the Insurance Rating Organization having jurisdiction, the serving electrical utility company, the latest edition of the National Electrical Code (NEC), the National Electric Manufacturers Association (NEMA), the Institute of Electrical and Electronic Engineers (IEEE), the Insulated Power Cable Engineers Association (IPCEA), the American Society of Testing Materials (ASTM), the American National Standards Institute (ANSI), the requirements of the Occupational Safety Hazards Act (OSHA), and all other applicable Federal, State and local laws and/or ordinances.
2. All material and equipment shall bear the inspection labels of Underwriters Laboratories, Inc., if the material and equipment is of the class inspected by said laboratories.
3. All work shall be in accordance with local codes.

B. Nonconformance

1. Any paragraph of requirements in these Specifications, or Drawings, deviating from the rules, requirements and Specifications of the above organizations shall be invalid and their (the above organizations) requirements shall hold precedent thereto. The CONTRACTOR shall be held responsible for adherence to all rules, requirements and specifications as set forth above. Any additional work or material necessary for adherence will not be allowed as an extra, but shall be included in the Bid Price. Ignorance of any rule, requirement, or Specification shall not be allowed as an excuse for nonconformity. Acceptance by the ENGINEER does not relieve the CONTRACTOR from the expense involved for the correction of any errors which may exist in the drawings submitted, or in the satisfactory operation of any equipment.

C. Certification

1. Upon completion of the work, the CONTRACTOR shall obtain certificate(s) of inspection and approval from the National Board of Fire Underwriters or similar inspection organization having jurisdiction and shall deliver same to the ENGINEER and the OWNER.

1.07 PERMITS AND INSPECTIONS

- A. The CONTRACTOR shall reference the General Conditions and Section 01010, Summary of Work.

1.08 TEMPORARY LIGHTING AND POWER

- A. The CONTRACTOR shall reference the General Conditions and Section 01510, Temporary Utilities.

1.09 TESTS

- A. Upon completion of the installation, the CONTRACTOR shall perform tests for operation, load (Phase) balance overloads, and short circuits. Tests shall be made with and to the satisfaction of the OWNER and ENGINEER.
- B. The CONTRACTOR shall perform all field tests and shall provide all labor, equipment, and incidentals required for testing and shall pay for electric power required for the tests. All defective material and workmanship disclosed shall be corrected by the CONTRACTOR at no cost to the OWNER. The CONTRACTOR shall show by demonstration in service that all circuits and devices are in good operating condition. Test shall be such that each item of control equipment will function not less than five (5) times.
- C. The grounding system shall be tested to assure continuity and compliance with the requirement that ground resistances do not exceed 5 ohms when measured by a megohmmeter or equivalent device. Ground resistance measurements of each grounding electrode shall be taken and certified by the CONTRACTOR. Upon completion of the Project, the CONTRACTOR shall submit to the ENGINEER the measured ground resistance of each ground rod and grounding system, indicating the location of the rod and grounding system as well as the resistance and soil conditions at the time the measurements were made. Ground resistance measurements shall be made in normally dry weather not less than 48 hours after rainfall and with the ground under test isolated from other grounds. Ground resistance shall also be measured from each piece of equipment to the grounding electrode. Reference Section 16170, Grounding and Bonding, for additional requirements.
- D. Each lighting and power distribution panelboard shall be tested with main circuit breaker disconnected from the feeder, branches connected, branch circuit breakers closed, all fixtures in place and permanently connected, lamps removed or omitted from the fixtures, and all wall switches closed.
- E. Testing (Insulation Resistance Test) of all incoming and outgoing cables for switchgears, distribution and power panels, motor control centers, and similar equipment shall be done after the cables are in place and just prior to final terminations. All data shall be recorded, as per Exhibit "A", attached to the end of this Section.
- F. The CONTRACTOR shall furnish all equipment and personnel as required.
- G. Feeder circuits shall be tested with the feeder conductors disconnected from the supplied equipment. Each individual power circuit shall be tested at the panel or motor control center with the power equipment connected for proper operation.
- H. Megohmmeter tests of the insulation resistance of rotating machines and power feeders shall be conducted. The results will be accepted when the megger shows the insulation

resistance to be not less than one megohm per 100 volts at 10°C using a 1,000-volt megger.

- I. All transformers shall be Megohmmeter tested in accordance with the manufacturer's recommendations.

1.10 DOCUMENTATION

- A. Required Documentation

The work requirements of this Section is in addition to and does not supersede testing and adjusting specified in other portions of the Contract Documents. The CONTRACTOR shall submit to the ENGINEER test records and reports for all testing.

1.11 FIELD TEST OF EQUIPMENT

- A. The equipment to be tested shall include, but not be limited to, the following:

- 480V Motor Control Centers
- Variable Frequency Drives and Related Motor Control Equipment
- Panelboards
- Conduit System
- Cable and Wire
- Grounding System
- General Purpose Dry Type Transformers

- B. Refer to each specific specification section for detailed field tests.

1.12 FINAL FIELD TEST OF SYSTEM

- A. The CONTRACTOR shall complete the installation and testing of the electrical installation at least two (2) months prior to the start-up and testing of all other equipment. During the period between the completion of electrical installation and the start-up and testing of all other equipment, the CONTRACTOR shall make all components of the Work available as it is completed for their use in performing Preliminary and Final Field Tests.
- B. Before each test commences, the CONTRACTOR shall submit a detailed test procedure, and also provide test engineer resume, manpower and scheduling information for the approval by the ENGINEER. In addition, the CONTRACTOR shall furnish detailed test procedures for any of his equipment required as part of the field tests of other systems.
- C. The CONTRACTOR shall perform an infrared inspection to locate and correct all heating problems associated with electrical equipment. The infrared inspection shall apply to existing and new equipment.

1.13 SCHEDULES AND PLANT OPERATIONS (NOT USED)

(EXHIBIT A) TEST DATA - MEGOHMS TEST NO. ____							
Date:			Company:				
Time:			Location:				
Circuit:	Circuit Length:	Aerial:	Duct:	Buried:	No. of Conductors	Size:	AMG MCM Shld:
Insulation Material:			Insulation Thickness:		Voltage Rating:		Age:
Type: ____ Pothead ____ Terminal					Location: Indoors____ Outdoors____		
Number and Type of Joints:							
Recent Operating History:							
Manufacturer:							
State if Potheads or Terminals were grounded during test:							
List associated equipment included in test:							
Miscellaneous Information:							

(EXHIBIT A)
TEST DATA - MEGOHMS
TEST NO. _____

Part Tested: Test Made: _____
Hours/Days: _____
After Shutdown: _____

Grounding Time: Dry Bulb Temperature: _____
Wet Bulb Temperature: _____

Test Voltage: _____

Equipment Temperature: _____
How Obtained: _____
Relative Humidity: _____
Absolute Humidity: _____
Dew Point: _____

Megohmmeter: Serial Number: _____ Range: _____
Voltage: _____ Calibration Date: _____

Test Connections	To Line To Earth To Ground	To Line To Earth To Ground	To Line To Earth To Ground	Test Connections	To Line To Earth To Ground	To Line To Earth To Ground	To Line To Earth To Ground
<input type="checkbox"/> Minute				5 Minutes			
<input type="checkbox"/> Minute				6 Minutes			
3/4 Minute				7 Minutes			
1 Minute				8 Minutes			
2 Minutes				9 Minutes			
3 Minutes				10 Minutes			
4 Minutes				10/1 Minutes			
				Ratio			

Remarks:

1.14 MATERIALS HANDLING

- A. Materials arriving on the job site shall be stored in such a manner as to keep material free of rust and dirt, and so as to keep material properly aligned and true to shape. Rusty, dirty, or misaligned material shall be rejected. Electrical conduit shall be stored to provide protection from the weather and accidental damage. Rigid non-metallic conduit shall be stored on even supports and in locations not subject to direct sun rays or excessive heat. Cables shall be sealed, stored, and handled carefully to avoid damage to the outer covering or insulation and damage from moisture and weather. Adequate protection shall be required at all times for electrical equipment and accessories until installed and accepted. Materials damaged during shipment, storage, installation, or testing shall be replaced or repaired in a manner meeting with the approval of the ENGINEER. The CONTRACTOR shall store equipment and materials in accordance with Section 01550, Site Access and Storage.

PART 2 -- PRODUCTS

2.01 PRODUCT REQUIREMENTS

- A. Unless otherwise indicated, the materials to be provided under this Specification shall be the products of manufacturers regularly engaged in the production of all such items and shall be the manufacturer's latest design. The products shall conform to the applicable standards of UL and NEMA, unless specified otherwise. International Electrotechnical Commission (IEC) standards are not recognized. Equipment designed, manufactured, and labeled in compliance with IEC standards is not acceptable.
- B. All items of the same type or ratings shall be identical. This shall be further understood to include products with the accessories indicated.
- C. All equipment and materials shall be new, unless indicated or specified otherwise.
- D. The CONTRACTOR shall submit proof if requested by the ENGINEER that the materials, appliances, equipment, or devices that he provides under this Contract meet the requirements of Underwriters Laboratories, Inc., in regard to fire and casualty hazards. The label of or listing by the Underwriters Laboratories, Inc., will be accepted as conforming with this requirement.

2.02 SUBSTITUTIONS

- A. Any reference in the Specifications or on the Drawings to any article, service, product, material, fixture, or item of equipment by name, make, or catalog number shall be interpreted as establishing the type, function, and standard of quality and shall not be construed as limiting competition. The CONTRACTOR, in such cases may, at his option use any article, device, product, material, fixture, or item of equipment which in the judgment of the ENGINEER, expressed in writing, is equal to that specified.

2.03 CONCRETE

- A. The CONTRACTOR shall furnish all concrete required for the installation of all electrical work, Concrete shall be as specified under Section 03300.

- B. The CONTRACTOR shall provide concrete equipment pads for all free standing electrical apparatus and equipment located on floors or slabs that are existing or provided by others. The CONTRACTOR shall provide all necessary anchor bolts, channel iron sills, etc. The exact location and dimensions shall be coordinated for each piece of equipment well in advance of the scheduled placing of these pads. Equipment pads shall be 4 inches high unless otherwise indicated on the Drawings. Pads shall be reinforced with steel wire mesh and shall have dowel rods inserted into the floor for anchorage.
- C. The CONTRACTOR shall provide concrete foundations for all free standing electrical apparatus and equipment located outdoors or where floors or slabs are not existing or provided by others. The CONTRACTOR shall provide all necessary anchor bolts, channel iron sills, etc. The location and dimensions shall be coordinated for each piece of equipment well in advance of the scheduled placing of the foundations. Equipment foundations shall be constructed as detailed on the Drawings or if not detailed on the Drawings shall be 6 inches thick minimum reinforced with #4 bars at 12-inch centers each way placed mid-depth. Concrete shall extend 6 inches minimum beyond the extreme of the equipment base and be placed on a compacted stone bed (#57 stone or ABC) 6 inches thick minimum.
- D. Concrete and reinforcing steel shall meet the appropriate requirements of Division 3 of the Specifications.

PART 3 -- EXECUTION

3.01 CUTTING AND PATCHING

A. Coordination

- 1. The work shall be coordinated between all trades to avoid delays and unnecessary cutting, channeling and drilling. Sleeves shall be placed in concrete for passage of conduit wherever possible.

B. Damage

- 1. The CONTRACTOR shall perform all chasing, channeling, drilling and patching necessary to the proper execution of his Contract. Any damage to the building or any equipment shall be repaired by qualified mechanics of the trades involved at the CONTRACTOR's expense. If, in the ENGINEER's judgment, the repair of damaged equipment would not be satisfactory, then the CONTRACTOR shall replace damaged equipment at his own expense.

3.02 EXCAVATION AND BACKFILLING

- A. The CONTRACTOR shall perform all excavation and backfill required for the installation of all electrical work. All excavation and backfilling shall be in complete accordance with the applicable requirements of Division 2.

3.03 CORROSION PROTECTION

- A. Wherever dissimilar metals come into contact, the CONTRACTOR shall isolate these metals as required with neoprene washers, nine (9) mil polyethylene tape, or gaskets.

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SECTION 16111

CONDUIT

PART 1 -- GENERAL

1.01 THE REQUIREMENT

- A. Under this Section, the CONTRACTOR shall furnish and install all conduits and conduit fittings to complete the installation of all electrically operated equipment as specified herein and as required.
- B. The Drawings indicate the general location of conduits both exposed and concealed; however, the CONTRACTOR shall install these conduits in such a manner to avoid all interferences.
- C. Reference Section 16000, Basic Electrical Requirements.

1.02 TESTING

- A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:
 - 1. Witnessed shop tests
 - a. None required.
 - 2. Field tests
 - a. Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 1, and Section 16000, Basic Electrical Requirements.
 - b. All conduit shall be tested to ensure continuity and the absence of obstructions by pulling through each conduit a swab brush followed by a mandrel 85% of the conduit inside diameter. After testing, all conduits shall be capped after installation of suitable pulling tape.

1.03 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the CONTRACTOR shall obtain from the equipment manufacturer and submit shop drawings. Each submittal shall be identified by the applicable Specification section.

1.04 SHOP DRAWINGS

- A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

- B. Partial, incomplete, or illegible submittals will be returned to the CONTRACTOR without review for resubmittal.
- C. Shop drawings shall include but not be limited to equipment specifications and product data sheets identifying all materials used and methods of fabrication.

PART 2 -- PRODUCTS

2.01 MANUFACTURERS

- A. The material covered by this Specification is intended to be standard material of proven performance as manufactured by reputable concerns. Material shall be fabricated, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as specified herein and shown on the Drawings.

2.02 CONDUITS

- A. Unless specified otherwise herein, or indicated on the Drawings, all conduits shall be rigid, aluminum. Minimum size conduit shall be 3/4 inch. Unless specified otherwise herein or indicated on the Drawings, all encased conduits shall be PVC Schedule 40, minimum size 1 inch. The CONTRACTOR, at his option, for ease of installation to accommodate saddle size, may increase the size of encased conduits to 2-inch. However, no combining of circuits/conductors will be permitted in these larger conduits.

All components of the conduit system shall be of the same material of construction. Aluminum conduit systems shall include fittings, couplings, connectors, and other components compatible with and approved for such systems. Coated conduit systems shall include factory coated fittings couplings, connectors, and other components compatible with and approved for coated conduit systems.

Reference the "Conduit Uses" portion of this specification for additional information regarding conduit.

B. Rigid Steel Conduit

- 1. Steel conduits shall be rigid type, heavy wall, hot-dipped galvanized inside and outside and as manufactured by Allied Tube and Conduit Corporation, Wheatland Tube Company, Jones & Laughlin Steel Company, or equal.
- 2. Each length of conduit shall be shipped with a coupling on one end and a color coded thread protector at the other end.

C. Aluminum Metal Conduit

- 1. Aluminum conduits shall be rigid type, heavy wall, hot dipped galvanized inside and outside and as manufactured by Allied Tube and Conduit Corporation, Wheatland Tube Company, Jones & Laughlin Steel Company, or equal.

D. Liquid-Tight Flexible Metal Conduit

1. Liquid-tight flexible conduit (LFMC) shall be galvanized steel, single strip, with a copper strip interwoven and suitable as a grounding means. LFMC shall be UL listed. LFMC shall have an extruded moisture and oil-proof PVC jacket. LFMC shall be Liqueflex Type "LA" as manufactured by Electri-Flex, "Ultratite" Type UL "Ultralite" as manufactured by Alfex Corporation, Type "A" as manufactured by Anaconda, or equal.
2. Watertight connectors shall be used with liquid-tight flexible metal conduit on both ends. LFMC shall be used to connect all vibrating equipment installed outdoors, in wet or damp areas, and other applications as directed by the ENGINEER.

E. Rigid Nonmetallic Conduit

1. Rigid nonmetallic conduit shall be Schedule 40 polyvinyl chloride (PVC), 90°C, UL rated and shall conform to NEMA TC-2. Fittings and conduit bodies shall conform to NEMA TC3.
2. Rigid non-metallic conduit shall be as manufactured by Carlon, Triangle Conduit and Cable, Cantex, Inc., or equal.

F. Electrical Metallic Tubing

1. Electrical metallic tubing shall meet ANSI C80.3 and shall be UL listed. The conduit shall be furnished and installed in accordance with Article 348 of the NEC. Electrical metallic tubing shall be manufactured by LTV Steel Tubular Products Company, "Electrunite", Triangular PWC, Inc., Allied Tube and Conduit Corporation, or equal.
2. The conduit shall be cold-rolled steel tubing with a zinc coating on the outside and protected on the inside by a zinc, enamel, or equivalent corrosion-resistant coating and conforming to the requirements of ANSI C 80.3, latest edition.

G. Conduit Fittings

1. Fittings for rigid metal conduit, rigid nonmetallic conduit, flexible metal conduit, liquid-tight flexible metal conduit, and electrical metallic tubing shall conform to UL 467 and UL 514 as applicable.
2. Fittings for electrical metallic tubing shall be rain-tight and concrete-tight, conform to UL 467 and UL 514, as applicable, and shall be plated steel hexagonal threaded compression type.
3. Set screw or indentor type connectors shall not be used. Fittings for conduit installed in wet locations and underground shall provide a watertight joint. Fittings for rigid conduit shall be threaded.
4. Fittings or bushings shall be installed in easily accessible locations.

5. Where exposed conduits pass through expansion joints, approved weatherproof telescopic type expansion fittings shall be used. Fittings shall be OZ/GEDNEY Type AX, or equal, watertight, permit a movement up to 4 inches, and shall be equipped with approved bonding jumpers around or through each fitting. Bonding jumpers shall be Appleton, Crouse-Hinds, OZ/Gedney, or equal.

Where embedded conduits pass through expansion joints, approved watertight, concrete-tight deflection/expansion fittings shall be used. Fittings shall compensate for movement of $\frac{3}{4}$ -inch from the normal in all directions. Fittings shall be OZ/GEDNEY Type DX, or equal.

Where embedded conduits pass through structural expansion joints, approved watertight, concrete-tight deflection/expansion fittings shall be used. Fittings shall compensate for movement of $\frac{3}{4}$ -inch from the normal in all directions. Fittings shall be OZ/GEDNEY Type DX, or equal.

6. Conduit fittings ("condulets") shall be used on exposed conduit work for lighting and power outlets, convenience outlets, changes in direction of conduit runs and breaking around beams. "Condulets" shall be cast ferrous alloy, galvanized or cadmium plated, as manufactured by Crouse-Hinds, OZ/Gedney, Appleton Company, or equal. Coated fittings and boxes shall be used with coated conduit in all chemically aggressive areas or where called for on the Drawings. Covers shall be of a design suitable for the purpose intended. In damp areas, the outside condulets shall be made watertight. Install all condulets with the covers accessible. Use proper tools to assemble conduit system to prevent injury to the plastic covering. No damage to the covering shall be permitted.
7. Conduit fittings shall be cast type of non-ferrous metal or malleable iron thoroughly coated inside and outside with metallic zinc or cadmium after all machining has been completed. Cast fittings shall be provided with heavy threaded hubs to fit the conduit required. Covers shall be of the same material as the fittings to which they are attached and shall be screwed on with rubber or neoprene gaskets between the covers and fittings. Cast fittings 1-1/2 inches and above shall be of the "mogul" type. Where cast fittings are used to house wiring devices such as receptacles and switches, they shall be of the "deep" type.
8. Conduit seals shall be Type EYS as manufactured by Crouse-Hinds, Appleton equivalent, OZ/Gedney equivalent, or equal.

PART 3 -- EXECUTION

3.01 CONDUIT AND FITTINGS

- A. Unless otherwise specified herein or indicated on the Drawings, the minimum size conduit shall be $\frac{3}{4}$ inch for exposed work and 1 inch for conduit encased in concrete or mortar.
- B. Conduit home runs for some lighting circuits are not necessarily indicated on the Drawings; however, the circuit numbers are shown. Conduit shall be furnished and installed for these lighting circuits and shall be installed as required to suit field conditions, subject to review and acceptance by the ENGINEER.

- C. Conduit shall be installed concealed unless otherwise indicated or specified. Conduit may be run exposed on walls only where concealing is not practical, or at the direction of the ENGINEER.
- D. Where exposed, maintain a minimum distance of 6 inches from parallel runs of flues or water pipes. Conduit runs shall be installed in such locations as to avoid steam or hot water pipes. A minimum separation of 12 inches shall be maintained where conduit crosses or parallels hot water or steam pipes.
- E. For floor mounted equipment, conduit may be run overhead and dropped down, where underfloor installation is not practical. Groups of conduits shall be uniformly spaced, where straight and at turns. Conduit shall be cut with a hacksaw or an approved conduit-cutting machine and reamed after threading to remove all burrs. Securely fasten conduit to outlets, junction and pull boxes to effect firm electrical contact. Join conduit with approved couplings. Conduits shall be freed from all obstructions.
- F. Empty conduit systems shall be furnished and installed as indicated on the Drawings and shall have pull wires installed. The pull wire shall be No. 14 AWG zinc-coated steel, or of plastic material, having not less than 200 pound tensile strength. Not less than 12 inches of slack shall be left at each end of the pull wire.
- G. Each piece of conduit installed shall be free from blisters or other defects. Each piece installed shall be cut square, taper reamed, and a coat of sealing compound applied to threads. Threads on conduits shall be painted with a conducting compound prior to making up in a fitting. Conduit connections shall be made with standard coupling and the ends of the conduit shall butt tightly into the couplings. In exposed work only, where standard coupling cannot be used, only Erickson couplings are permitted, or as otherwise acceptable to the ENGINEER.
- H. Conduit threaded in the field shall be of standard sizes and lengths.
- I. All bends shall be made with standard factory conduit elbows or field bent elbows. Field bending of conduit shall be done using tools approved for the purpose. Heating of conduit to facilitate bending is prohibited. Field bends shall be not less than the same radius than a standard factory conduit elbow. Bends with kinks shall not be acceptable.

The equivalent number of 90° bends in a single conduit run are limited to the following:

- | | |
|----------------------------------|---|
| 1. Runs in excess of 300 feet: | 0 |
| 2. Runs of 300 feet to 201 feet: | 1 |
| 3. Runs of 200 feet to 101 feet: | 2 |
| 4. Runs of 100 feet and less: | 3 |

- J. Unless otherwise specified herein, indicated on the Drawings, or required by the NEC, conduit shall be supported every 8 feet and shall be installed parallel with or perpendicular to walls, structural members, or intersections of vertical planes and ceilings with right angle turns consisting of fittings or symmetrical bends. Conduits shall be supported within 1 foot of all changes in direction. Supports shall be approved pipe

straps, wall brackets, hangers or ceiling trapeze. All fasteners, clamps, straps, and anchors shall be stainless steel. The use of perforated strap hangers or Mineralac conduit hangers are prohibited. Perforated strap hangers shall not be used. In no case shall conduit be supported or fastened to another pipe or installed to prevent the removal of other pipe for repairs. Fastenings shall be by expansion bolts on concrete; by machine screws, welded threaded studs, or spring-tension clamps on steel work. Explosive-drive equipment may be used to make connections where the use of this equipment complies with safety regulations. Wooden plugs inserted in masonry and the use of nails as fastening media are prohibited. Threaded C-clamps may be used on rigid conduit only. Conduits or pipe straps shall not be welded to steel.

- K. The load applied to fasteners shall not exceed 1/4 of the proof test load. Fasteners attached to concrete ceilings shall be vibration and shock resistant. Holes cut to a depth of more than 1-1/2 inches in reinforced concrete beams or to a depth of more than 3/4 inch in concrete joints shall not cut the main reinforcing bars. Holes not used shall be filled. Spring steel fasteners may only be used to support lighting branch circuit conduits to structural steel members. Conduits shall be fastened to all sheet metal boxes and cabinets with two (2) locknuts where required by the National Electrical Code to insure adequate bonding for grounding. Where insulated bushings are used, or where bushings cannot be secured firmly to the box or enclosure, a bonding jumper shall be installed to maintain suitable grounding continuity. Locknuts shall be the type with sharp edges for digging into the wall of metal enclosures. Bushings shall be installed on the ends of all conduits and shall be of the insulating type where required by the National Electrical Code.
- L. Conduit installed in concrete floor slabs or walls shall be located so as not to affect the designed structural strength of the slabs. Conduit shall be installed within the middle one-third of the concrete slab except where necessary to not disturb the reinforcement. The outside diameter of conduit shall not exceed one-third of the slab thickness, and conduits shall be spaced no closer than three (3) diameters except at cabinet locations. Curved portions of bends shall not be visible above the finish slab. Where embedded conduits cross expansion joints, suitable watertight expansion fittings and bonding jumpers shall be provided. Conduit larger than 1-inch trade size shall be parallel with or at right angles to the main reinforcement. When at right angles to the reinforcement, the conduit shall be close to one of the supports of the slab. Conduits shall not be stacked more than two (2) diameters high in floor slabs.
- M. Install rigid aluminum conduits when entering or exiting concrete except under electrical equipment where the conduit is not subject to physical abuse. Extend stub-ups at least 12 inches above and below grade or finish floor. Conduits extending through the concrete floor shall be installed using straight runs (for vertical penetrations) or factory elbows (for conduits installed within the slab) of rigid aluminum conduit.
- N. All conduit extending through the floor behind panels or into control centers or similar equipment may be PVC Schedule 40 and shall extend a minimum of 6 inches above the floor elevations, where practicable, with no couplings at floor elevations.
- O. Unless specifically identified on the Drawings as "Direct Buried," all conduits in the earth, including conduits below slabs-on-grade, shall be concrete encased. Joints in conduit shall be staggered so as not to occur side by side. Rigid non-metallic (PVC) conduit shall be connected to rigid aluminum conduit at the point where it leaves the ground, with the transition to metal conduit occurring inside the concrete encasement.

- P. No more than three (3) 90 degree bends will be allowed in any one conduit run. Where more bends are necessary, a conduit or pull box shall be installed. All bends in 1/2-inch and 3/4-inch conduit shall be made with a conduit bender, and all larger sizes shall have machine bends. Joints in threaded conduit shall be made up watertight with the appropriate pipe thread sealant or compound applied to male threads only; and, all field joints shall be cut square, reamed smooth, and properly threaded to receive couplings. No running threads are permitted. All conduit ends at switch and outlet boxes shall be fitted with an approved locknut and bushing forming an approved tight bond with box when screwed up tightly in place.
- Q. Conduits stubbed up through concrete floors for connections to freestanding equipment and for future equipment shall be provided with an adjustable top or coupling threaded inside for plugs, set flush with the finished floor. Wiring shall be extended in rigid metal conduit to equipment except that, where required, flexible metal conduit may be used 6 inches above the floor. Screwdriver operated threaded flush plugs shall be installed in conduits from which no equipment connections are made.
- R. Where outlets are shown near identified equipment furnished by this or other Contractors, it is the intent of the Specifications and Drawings that the outlet be located at the equipment to be served. The CONTRACTOR shall coordinate the location of these outlets to be near the final location of the equipment served whether placed correctly or incorrectly on the Drawings. Changes in outlet locations required to serve the equipment furnished by other Contractors on the Project shall be brought to the attention of the ENGINEER.
- S. Conduit shall be protected immediately after installation by installing flat non-corrosive metallic discs and steel bushings, designed for this purpose, at each end. Discs shall not be removed until it is necessary to clean the conduit and install the conductors. Before the conductors are installed, insulated bushings shall be installed at each end of the conduit.
- T. Where "all-thread" nipples are used between fittings and electrical equipment, they shall be so installed that no threads are exposed.
- U. Connections from rigid conduit to motors and other vibrating equipment, limit switches, solenoid valves, level controls, and similar equipment, shall be made with short lengths of liquid-tight flexible metal conduit. These conduits shall be installed in accordance with the NEC and shall be furnished and installed with appropriate connectors with devices which will provide an excellent electrical connection between the equipment and the rigid conduit for the flow of ground current. Flexible metal conduit and liquid-tight flexible metal conduit length shall be five feet (5 feet), maximum.
- V. Flexible metal conduit or liquid-tight flexible metal conduit installed between rigid metal conduit and motor terminal box and/or any other apparatus shall have a green insulated grounding conductor running through flexible conduit. This conductor shall be terminated to the nearest pull box, motor terminal box, or any other apparatus ground terminal.
- W. All threaded ends of conduits shall be coated with an approved conducting compound as manufactured by Thomas & Betts, or equal prior to making up the joint.

- X. Conduits installed within or underneath floor slabs, underground direct-buried or concrete encased conduits, and all conduits installed in areas subject to liquid inadvertently entering the conduit system shall be sealed or plugged at both ends in accordance with NEC Article 300-5(g). This requirement applies to both conduits containing conductors and "spare" conduits. Where practicable, the interior of the conduit shall be sealed as well as around the conductors by using conduit sealing bushings: Type CSB as manufactured by O/Z Gedney, or equal. Where the conduit fill does not allow the use of these bushings, the conduits shall be tightly caulked or plugged.

Conduit passing through the walls and floors of buildings below grade shall be installed with appropriate watertight fittings to prevent the entrance of ground water around the periphery of the conduits. For vertical conduit penetrations through openings in concrete floors, the fittings shall be Type FSK Floor Seals as manufactured by OZ/Gedney. For conduit penetrations through openings in concrete walls, the fittings shall be Type WSK Thruwall seals as manufactured by OZ Gedney. Conduits shall be sloped away from the buildings toward splice boxes, handholes and/or manholes to provide drainage away from the building wall.

Conduits passing through sleeves in interior walls and floors shall be tightly caulked.

- Y. Weatherproof, insulated throat "Meyers" hubs shall be used on all conduit entries to boxes and devices without integral hubs in process areas to maintain NEMA 4X integrity. The CONTRACTOR shall furnish and install "Meyers" hubs on all conduit entries into non-cast enclosures such as metallic or non-metallic control panels, control component enclosures, wireways, pull boxes, junction boxes, control stations, and similar type equipment when this type of equipment is located in process areas requiring NEMA 4X integrity. This specified requirement for "Meyers" hubs does not apply to any area of the plant facilities where NEMA 4X integrity is not required.
- Z. The use of two (2) locknuts and a grounding bushing shall be required at all conduit terminations where hub type fittings are not required; such as electrical rooms, control rooms, and office areas.
- AA. Conduit installation shall be arranged to minimize cleaning. No horizontal runs of conduit will be permitted in brick or masonry walls.
- AB. Install non-metallic conduits in accordance with manufacturer's instructions where specified herein or indicated on the Drawings.
- AC. Join non-metallic conduit using cement as recommended by the manufacturer. Clean and wipe non-metallic conduit dry before joining. Apply full even coat of cement to entire area inserted in fitting. Allow joint to cure for twenty (20) minutes (minimum).
- AD. Conduits passing through the walls and floors of buildings below grade shall be installed with appropriate watertight fittings to prevent the entrance of ground water around the periphery of the conduits. For vertical conduit penetrations through openings in concrete floors, the fittings shall be Type CSMC conduit sealing busing or Type FSK floor seal as manufactured by OZ/Gedney. Conduit penetrations through walls shall be furnished and installed with Type WSK Thruwall seals as manufactured by OZ/Gedney. Conduits shall be sloped away from the buildings toward splice boxes, handholes and/or manholes to

provide drainage away from the building wall. Conduit seals as specified above shall be provided for where conduits pass through walls on new and existing structures.

- AE. Power wiring conduits shall be separated from signal wiring as indicated in table in Section 17000 paragraph 17080.109.H.

3.02 CONDUIT USES AND APPLICATIONS

- A. No PVC conduit shall be installed exposed unless specifically accepted in writing by the ENGINEER. Where PVC conduit is allowed to be installed exposed, the conduit shall be Schedule 80 as required by the NEC. Reference Article 300-5(d) of the NEC.
- B. PVC Schedule 40 conduit shall be installed in reinforced concrete encasement if subject to vehicular traffic and in non-reinforced concrete encasement if not subject to vehicular traffic. Conduit shall be "direct buried" only if specifically indicated on the Drawings.
- C. PVC Schedule 40 conduit shall be furnished and installed in concrete slabs (for slab-on-grade construction) and in walls when the conduit is shown to be encased. Rigid steel conduit shall be installed in all elevated slabs when the conduits are shown to be encased.
- D. All instrumentation wire and cable for analog signals shall be installed in rigid steel conduit. This applies to all conduit installations including exposed, concealed in concrete encasement, and all other applications.
- E. Rigid aluminum conduit shall be furnished and installed, where exposed.
- F. Other conduit uses not specifically listed above shall be brought to the attention of the ENGINEER for a decision.

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SECTION 16123

BUILDING WIRE AND CABLE

PART 1 -- GENERAL

1.01 THE REQUIREMENT

- A. The CONTRACTOR shall furnish, install, connect, test, and place in satisfactory operating condition, ready for service, all cables and wires indicated on the Drawings and as specified herein or required for proper operation of the installation, with the exception of internal wiring provided by electrical equipment manufacturers. The work of connecting cables to equipment, machinery, and devices shall be considered a part of this Section. All hardware, junction boxes, bolts, clamps, insulators, and fittings required for the installation of cable and wire systems shall be furnished and installed by the CONTRACTOR.
- B. The CONTRACTOR shall submit Shop Drawings and other material required to substantiate conformance with the requirements set forth on the Drawings and in Section 16000, Basic Electrical Requirements, and Section 01300, Submittals. Shop drawings shall include, but not be limited to, detailed specifications and product data sheets for the power, control, and instrumentation cable required for this project.
- C. The wire and cable to be furnished and installed for this project shall be the product of manufacturers who have been in the business of manufacturing wire and cable for a minimum of ten (10) years.
- D. Reference Section 16000, Basic Electrical Requirements.

1.02 TESTING

- A. All testing shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:
 - 1. Witness Shop Tests
 - a. Not required.
 - 2. Shop Test
 - a. Prior to the first shipment of each size of power, control, and instrumentation cable to be furnished and installed under this Contract, samples of each size of cable shall be subjected to complete physical and electrical factory production tests at the manufacturer's plant. Other cable and wiring shall be tested in accordance with the applicable ICEA Standards. Six copies of certified test data sheets shall be submitted to the ENGINEER for approval prior to installation at the site. Subsequent shipment of each size of wire shall be covered by certificates of

compliance which shall list CONTRACTOR's name, point of delivery, reel numbers, size of wire, length of wire, and date of shipment. Certificates shall attest the wires and cables comply with specification requirements and that wires and cables are equal in every respect to wires and cables which have been successfully tested.

- b. All test data or certificates shall be submitted.

3. Field Tests

- a. Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 1, and Section 16000, Basic Electrical Requirements.
- b. After installation, all wires and cables shall be tested for insulation levels and continuity. Insulation resistance between conductors of the same circuit and between conductor and ground shall be tested. Testing for insulation levels shall be as follows:
 - 1. For 600V power and control cable, apply 1,000 VDC from a Megaohmmeter for all 600V wires and cables installed in lighting, control, power, indication, alarm and motor feeder circuits. Testing for continuity shall be "test light" or "buzzer".
 - 2. 600V instrumentation signal cable shall be tested from conductor to conductor, conductor to shield, and conductor to ground using a Simpson No. 260 volt-ohmmeter, or approved equal. The resistance value shall be 200 Megaohms or greater.

- B. Low voltage wires and cables shall be tested before being connected to motors, devices or terminal blocks.
- C. Voltage tests shall be made successively between each conductor of a circuit and all other conductors of the circuit grounded.
- D. If tests reveal defects or deficiencies, the CONTRACTOR shall make the necessary repairs or shall replace the cable as directed by the ENGINEER, without additional cost to the OWNER.
- E. All tests shall be made by and at the expense of the CONTRACTOR who shall supply all testing equipment.

1.03 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the CONTRACTOR shall obtain from the wire and cable manufacturer and submit the following:

- 1. Shop Drawings

2. Reports of Certified Shop and Field Tests

3. Wiring Identification Methods

B. Each submittal shall be identified by the applicable specification section.

1.04 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed material's compliance with the Contract Documents.

B. Partial, incomplete, or illegible Submittals will be returned to the CONTRACTOR without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. Product data sheets.

2. Cable pulling calculations.

3. Wiring identification methods and materials.

1.05 IDENTIFICATION

A. Each cable shall be identified as specified in Part 3, Execution, of this Specification.

1.06 CABLE PULLING LUBRICANTS

A. The CONTRACTOR shall submit a list with a minimum of four manufacturer's standard lubricants which may be used interchangeably for each type of lubricant required. Lubricant shall be non-hardening type.

1.07 CABLE PULL CALCULATIONS

A. The CONTRACTOR shall submit cable pulling calculations. These calculations, to be performed by a currently registered professional engineer in the State of Florida, shall define pulling tension and sidewall loading (sidewall bearing pressure values) for all installations of 600VAC, #1/0 conductors and larger greater than 200 feet in length. Calculations for straight horizontal installations of 600VAC, #1/0 conductors and larger greater than 200 feet are not required.

PART 2 -- PRODUCTS

2.01 MANUFACTURERS

A. The wire and cable covered by this Specification is intended to be standard equipment of proven performance as manufactured by the Okonite Company, Rome Cable Corporation, Southwire Company, or equal. Wire and cable shall be designed,

constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as specified herein and shown on the Drawings. Only one manufacturer for each wire and cable type shall be permitted.

2.02 600 VOLT POWER WIRE AND CABLE

- A. 600 volt cable and wire shall consist of stranded, copper conductor with insulation rated THHN, 90°C for dry locations and THWN, 75°C for wet locations. For conductors No. 12 and No. 10 AWG and smaller, larger conductors shall have XHHW-2 insulation.
- B. Conductors shall be tin or alloy coated (if available), stranded copper per ASTM-B8 and B-33, and Class B or C stranding contingent on the size unless otherwise specified. Minimum size wire shall be No. 12 AWG.
- C. Uncoated conductors shall only be allowed if specifically accepted by the ENGINEER.
- D. 600 volt individual power wire and cable shall be Okoseal-N as manufactured by the Okonite Company, Rome Cable Corporation equivalent, Southwire Company equivalent, or equal. Multi-conductor power cables shall be Okoseal-N Type TC Cable as manufactured by the Okonite Company, Rome Cable Corporation equivalent, Southwire Company equivalent, or equal.

2.03 600 VOLT CONTROL CABLE

- A. 600 volt control cable shall consist of stranded, copper conductor with insulation rated THHN, 90°C for dry locations and THWN, 75°C for wet locations. The individual conductors of the multiple conductor cable shall be color coded for proper identification. Color coding shall be equal to ICEA S-68-514, Table K-1. Cables shall meet requirements of IEEE-383.
- B. Conductors shall be tin or alloy coated (if available) stranded copper per ASTM B-8 and B-33, and Class B or C stranding contingent on the size unless otherwise specified. Minimum wire size shall be No. 14 AWG.
- C. Uncoated conductors shall only be allowed if specifically accepted by the ENGINEER.
- D. 600 volt individual conductor control wire shall be Okoseal-N as manufactured by the Okonite Company, Rome Cable Corporation equivalent, Southwire Company equivalent, or equal. Multi-conductor control cable shall be Okoseal-N Type TC Cable as manufactured by the Okonite Company, Rome Cable Corporation equivalent, Southwire Company equivalent, or equal.

2.04 LIGHTING AND RECEPTACLE WIRE AND CABLE

- A. The lighting and receptacle branch circuit wire shall consist of stranded, copper conductors with insulation rated THHN, 90°C for dry locations and THWN, 75°C for wet locations.

- B. Conductors shall be tin or alloy coated (if available), stranded copper per ASTM-B8 and B-33, and Class B or C stranding contingent on the size unless otherwise specified. Minimum size wire shall be No. 12 AWG.
- C. Uncoated conductors shall only be allowed if specifically accepted by the ENGINEER.
- D. Lighting and receptacle cables and wire shall be Okoseal-N as manufactured by the Okonite Company, Rome Cable Corporation equivalent, Southwire Company equivalent, or equal.

2.05 INSTRUMENTATION CABLE

- A. The instrumentation cable for analog signals shall be single, shielded, twisted pairs or triads with 600 volt insulation and shall have a 90°C insulation rating.
- B. Conductors shall be tin or alloy coated (if available), soft, annealed copper, stranded per ASTM-B8, Class B stranding unless otherwise specified. Minimum size wire shall be No. 16 AWG.
- C. The instrumentation cable shall be Okoseal-N Type P-OS for single pair or triad applications and Okoseal-N Type SP-OS for multiple pair or triad applications as manufactured by the Okonite Company, Rome Cable Corporation equivalent, Southwire Company equivalent, or equal.

PART 3 -- EXECUTION

3.01 600V CABLE INSTALLATION

- A. The cable and wires shall be installed as specified herein and shown on the Drawings.
- B. The cables shall be terminated in accordance with the cable and/or termination product manufacturer's instructions for the particular type of cable.
- C. To minimize oxidation and corrosion, wire and cable shall be terminated using an oxide-inhibiting joint compound recommended for "copper-to-copper" connections. The compound shall be Penetrox E as manufactured by Burndy Electrical, or equal.
- D. Splices shall not be allowed in the underground manhole and handhole systems. If splices are required, the CONTRACTOR shall obtain approval in writing from the ENGINEER prior to splicing. Splicing materials shall be barrel type butt splice connectors and heat shrink tubing as manufactured by 3M, Ideal, or equal. No splicing of instrumentation cable is allowed. The use of screw-on wire connectors (wire nuts) for power or control wiring will only be permitted if specifically accepted by the ENGINEER. Reference Section 16130 for additional requirements regarding control wiring.
- E. Wire and Cable Sizes
 - 1. The sizes of wire and cable shall be as shown on the Drawings, or if not shown, as approved by the ENGINEER. If required due to field routing, the size of

conductors and respective conduit shall be increased so that the voltage drop does not exceed 2-1/2%.

2. Minimum wire size within control panels, motor control centers, switchboards and similar equipment shall be No. 12 AWG for power and No. 14 AWG for control.

F. Number of Wires

1. The number of wires indicated on the Drawings for the various control, indication, and metering circuits were determined for general schemes of control and for particular indication and metering systems.
2. The actual number of wires installed for each circuit shall, in no case, be less than the number required; however, the CONTRACTOR shall add as many wires as may be required for control and indication of the actual equipment selected for installation at no additional cost to the OWNER. The addition of conductors shall be coordinated with and approved by the ENGINEER to avoid violations of the NEC regarding conduit fill.
3. All spare field conductors shall be terminated on the terminal blocks mounted within the equipment.

G. Wiring Identification

1. All wiring shall be identified at each termination, shall have a unique wire number, and shall be labeled at both ends. Wire numbers shall correspond with the equipment terminal wire numbers as indicated in the accepted Shop Drawings. Where no wire numbers are indicated, the CONTRACTOR shall advise the ENGINEER in writing prior to assigning wire numbers. Wire numbers shall not be duplicated.
2. In addition to color coding, for all 1-phase and 3-phase systems, identify each cable (single or multi-conductor) and conductor at each end, in each manhole, pullbox, cable tray, or other component of the raceway system. This identification is applicable to all power, control, alarm, signal, and instrumentation cables, and conductors.
3. Identify each cable (single or multi-conductor) and groups or bundles of individual single conductors in each manhole, pullbox, cable tray or other component of the raceway system with circuit identification markers. Implement a "from-to" cable/conductor bundle tagging system as part of this identification effort.
4. For instrumentation wiring, the CONTRACTOR shall provide, on the Shop Drawings, a schedule indicating the wire number, color code, if applicable, origin and destination devices, and terminals. Instrumentation wire numbers shall contain as a minimum the signal tag indicated in the I/O schedule.
5. Wire identification shall be accomplished through the use of a portable printer and white, polyolefin wire marking sleeves. The wire identification system shall

be a "Bradymarker" XC Plus Printer with "Bradysleeve" wire marking sleeves, Panduit equivalent, Seton equivalent, or equal.

6. The CONTRACTOR shall submit a written description outlining his intended method of wiring identification and supporting information (i.e., product data sheets, etc.) identifying the materials to be used. The CONTRACTOR shall meet with the OWNER and the ENGINEER to come to an agreement regarding wire identification prior to the installation of any wiring.

H. Cable Identification Tags

1. The CONTRACTOR shall furnish all labor and materials and affix in a permanent way to each cable in manholes, cable compartments and vaults, junction boxes, pull boxes and points of termination, a bronze metal tag, 1/2-inch in diameter, with a 1/8-inch diameter hole, with copper wire through the hole, the cable identification number approved by the ENGINEER. The tag shall be attached to the cable by twisting the ends of the copper wires. All cables shall be tagged with its full ID number immediately after it has been pulled.

I. Cable Installation

1. All interior cable not protected by a compartment enclosure shall be run in conduit.

J. Wiring Supplies

1. Only electrical wiring supplies manufactured under high standards of production and meeting the approval of the ENGINEER shall be used.
2. Rubber insulating tape shall be in accordance with ASTM Des. D119. Friction tape shall be in accordance with ASTM Des. D69.

K. Training of Cable

1. The CONTRACTOR shall furnish all labor and material required to train cables around cable vaults within buildings and in manholes and handholes in the outdoor underground duct system. Sufficient length of cable shall be provided in each handhole, manhole, and vault so that the cable can be trained and racked in an approved manner. Instrumentation cable shall be racked separate from all other AC and DC wiring to maintain the required separation specified herein. In training or racking, the radius of bend of any cable shall be not less than the manufacturer's recommendation. All manhole cables shall be arc and fire-proofed. The training shall be done in such a manner as to minimize chaffing.

L. Connections at Control Panels, Limit Switches, and Similar Devices

1. Where stranded wires are terminated at panels, and/or devices, connections shall be made by solderless lug, crimp type ferrule, or solder dipped.

2. Where enclosure sizes and sizes of terminals at limit switches, solenoid valves, float switches, pressure switches, temperature switches, and other devices make 7-strand, No. 12 AWG, wire terminations impractical, the CONTRACTOR shall terminate external circuits in an adjacent junction box of proper size and complete with terminal strips and shall install No. 14 AWG stranded wires from the device to the junction box in a conduit. The #12 AWG field wiring shall also be terminated in the same junction box to complete the circuit.

M. Pulling Temperature

1. Cable shall not be flexed or pulled when the temperature of the insulation or of the jacket is such that damage will occur due to low temperature embrittlement. When cable will be pulled with an ambient temperature within a three day period prior to pulling of 40°F or lower, cable reels shall be stored during the three day period prior to pulling in a protected storage area with an ambient temperature not lower than 55°F and pulling shall be completed during the work day for which the cable is removed from the protected storage.

N. Color Coding

1. Conductor insulation shall be color coded as follows:

- a. 480V AC Power

Phase A - BROWN
Phase B - ORANGE
Phase C - YELLOW
Neutral - WHITE

- b. 120/208V or 120/240V AC Power

Phase A - BLACK
Phase B - RED
Phase C - BLUE
Neutral - WHITE

- c. DC Power

Positive Lead - RED
Negative Lead - BLACK

- d. DC Control

All wiring - BLUE

- e. 120VAC Control

Single conductor 120 VAC control wire shall be RED except for a wire entering a motor control center compartment or control panel which is an interlock. This conductor shall be color coded YELLOW.

f. 24VAC Control

All wiring - ORANGE

g. Equipment Grounding Conductor

All wiring - GREEN

2. Conductors No. 2 AWG and smaller shall be factory color coded with a separate color for each phase and neutral, which shall be used consistently throughout the system. Larger cables shall be coded by the use of colored tape.

3.02 INSTRUMENTATION CABLE INSTALLATION

- A. The CONTRACTOR shall install all cable or conductors used for instrumentation wiring (4-20 mA DC, etc.) in rigid galvanized steel or PVC coated rigid galvanized steel conduit. The use of asbestos cement or plastic conduit will not be permitted. Analog signal wires shall exclusively occupy these conduits. No other wiring for AC or digital DC circuits shall be installed in these conduits.
- B. All shielding shall be continuous and shall be grounded in accordance with the instrumentation equipment manufacturer's recommendations, as approved.
- C. A raceway containing instrumentation cable shall be installed to provide the following clearances:
1. Raceway installed parallel to raceway conductors energized at 480 through 208 volts shall be 18 inches and 208/120 volts shall be 12 inches.
 2. Raceway installed at right angles to conductors energized at 480 volts or 120/208 volts shall be 6 inches.
- D. Where practical, raceways containing instrumentation cable shall cross raceway containing conductors of other systems at right angles.
- E. Where instrumentation cables are installed in panels, manholes, handholes, and other locations, the CONTRACTOR shall arrange wiring to provide maximum clearance between these cables and other conductors. Instrumentation cables shall not be installed in same bundle with conductors of other circuits.
- F. Grounding of cable shield shall be accomplished at one point only, unless otherwise required by instrumentation system's manufacturer.
- G. Additional pullboxes shall be furnished and installed for ease of cable pulling and the cable manufacturer's recommended conduit fill factor shall be followed. Where required for specifically directed by the ENGINEER, the CONTRACTOR shall moisture seal the cables at all connections with OZ Gedney Type "CSB", or equal, sealing bushings.

- H. Special instrument cable shall be as specified or recommended by the vendor of the equipment or instruments requiring such wiring. Installation, storage, terminations, etc., shall be per manufacturer's recommendations.
- I. All cable, insulation and jacket shall have adequate strength to allow for it to be pulled through the conduit systems. Sufficient conductors shall be installed to provide space and serve future equipment where shown and specified. All conductors shall be color coded and all wires shall be suitably tagged with permanent markers at each end.

3.03 SCHEDULES

- A. The conduit schedules on the Drawings list conduit size, wire size, type and number required.
- B. All conduits and wiring shall be furnished and installed under this Contract.
- C. The definition of the term conduit shall include all types of raceways used on this project.
- D. In all cases where the work install or installed refers to conduit, it shall mean install all conduit, raceways, fittings, supports, boxes and appurtenances. In addition it shall include all grounding and bonding. Pull cords are to be pulled upon completion of each raceway.
- E. Where install or installed refers to cable, it shall include pulling the cable and testing the cable for insulation resistance, continuity and absence from grounds, as well as terminating all conductors and testing for proper connection.
- F. The conduit and cable schedules do not indicate all of the conduit and cable required for the project. The CONTRACTOR is advised to refer to these Specifications and Drawings for the additional conduit and cable requirements. All lighting, receptacle and control circuits may require field routing by the CONTRACTOR.
- G. The CONTRACTOR shall furnish and install a 250-lb. tested polyethylene pull-cord in each empty conduit and conduits to be utilized by others. The line shall be provided with a minimum of 8 inches of slack doubled back into the conduit. The conduit shall then be capped.
- H. Conduits leaving or entering a building may be shown in a different arrangement as compared to the duct bank. The CONTRACTOR shall arrange conduits penetrating the building based on field conditions. The plan drawings are not meant to represent actual conduit arrangements required. Furthermore, spare conduits from duct banks into buildings are required and shall be furnished and installed based on field conditions and Engineer approval.
- I. Certain runs of underground duct banks are not detailed, such as site lighting home runs, but all underground ducts shall comply with the requirements of these Specifications."

- END OF SECTION -

SECTION 16130

BOXES

PART 1 -- GENERAL

1.01 THE REQUIREMENT

- A. The CONTRACTOR shall furnish all labor, materials, tools and equipment necessary for furnishing, installing, connecting, testing and placing into satisfactory operation all pull, junction and outlet boxes for power, lighting and control as required for a complete electrical installation as shown on the Drawings and specified herein.
- B. Coordination
 - 1. The CONTRACTOR shall review installation procedures under other Divisions and coordinate them with the Work specified herein.
 - 2. The CONTRACTOR shall notify others in advance of the installation of the Work included herein to provide them with sufficient time for the installation and coordination of interrelated items that are included in the Contract and that must be installed in conjunction with the Work included in this Division.
- C. Boxes shall conform to all applicable Federal, UL and NEMA standards. Materials and components shall be new and conform to grades, qualities and standards as specified herein and shown on the Drawings.
- D. Reference Section 16000, Basic Electrical Requirements.

1.02 TESTING

- A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:
 - 1. Witnessed Shop Test
 - a. None required.
 - 2. Field Tests
 - a. Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 1, and Section 16000, Basic Electrical Requirements.

1.03 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the CONTRACTOR shall obtain from the equipment manufacturer(s) and submit the following:

1. Shop Drawings

- B. Each submittal shall be identified by the applicable specification section.

1.04 SHOP DRAWINGS

- A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.
 - B. Partial, incomplete or illegible Submittals will be returned to the CONTRACTOR without review for resubmittal.
 - C. Shop drawings shall include but not be limited to:
 1. Product data sheets.
 2. Complete assembly, layout, and installation drawings for each box with clearly marked dimensions.

PART 2 -- PRODUCTS

2.01 MANUFACTURERS

- A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

2.02 PULL, JUNCTION, AND OUTLET BOXES

- A. Exposed Indoor Wet Process and Outdoor Areas
 1. Exposed outlet boxes and junction boxes for outdoor and indoor wet process areas used for lighting fixtures, switches, and receptacles shall be of cast, rust-resisting metal provided with rubber or neoprene gasketed covers of similar metal. The completed units shall be of NEMA 4X construction and of ample size to house the required devices.
 - B. Concealed
 1. Outlet boxes for concealed work shall be a minimum of 4 inches square and 2 inches deep consisting of zinc coated pressed steel provided with knockouts for the conduit required. Boxes shall be provided with approved covers or plastic rings where necessary.
 2. Boxes for housing receptacles, switches and similar devices shall be of the deep type.

C. Indoors

1. Pull and junction boxes for indoor exposed use in dry locations shall be galvanized sheet steel with neoprene gasketed screwed-on covers and of all welded construction.

D. Miscellaneous

1. The CONTRACTOR shall furnish and install enclosures for housing interfacing and transition equipment, or other equipment requiring an enclosure. The CONTRACTOR shall be responsible for mounting the enclosure. The enclosures shall be a low profile type, weatherproof, lockable, and securely mounted to a concrete support pad using anchoring devices by Unistrut, Kendorf, B-Line Systems, Inc., or equal. The enclosures shall be furnished and installed in complete compliance with the NEC and with all state and local codes. The single door enclosure shall be finished with light gray epoxy paint and shall be manufactured by Hoffman, Rittal, The Austin Company, or equal.
2. All welded, galvanized, sheet steel boxes with neoprene gasketed screwed-on covers may be used outdoors in non-hazardous areas only where specified herein or indicated on the Drawings.
3. For outdoor and indoor wet process area use, NEMA 4X junction and pull boxes shall be provided. Boxes shall be equipped with neoprene gasketed covers which have been crossed ribbed and checkered. Boxes shall be provided with removable covers. Stainless steel cover screws are required. Boxes shall match the conduit to which attached.
4. For boxes shown or required in hazardous locations, boxes shall be furnished and installed in accordance with the Class, Division, and Group suitable for the application.

E. Galvanizing

1. The inside and outside surface of the boxes and covers shall be hot dipped galvanized after fabrication.

F. Box Sizes

1. The minimum size of boxes shall be according to the NEC. No box shall be filled to more than 40% of capacity.

G. Barriers

1. Galvanized steel or aluminum barriers shall be provided in junction or pull boxes to isolate conductors of different voltages and functions. Isolation shall be provided between the following groups:
 - a. Power (480 and 120 volts)
 - b. Control wiring

- c. Instrumentation wiring (twisted, shielded pairs or triads)
- 2. Barriers shall be provided in multi-gang outlet boxes when the voltage between switches exceeds 300 VAC.

PART 3 -- EXECUTION

3.01 INSTALLATION

A. Outlet Boxes

- 1. All outlet boxes required for supporting lighting fixtures shall be provided with fixture studs of sizes suitable for supporting the weight of the fixtures connected thereto. Fixture studs shall not be less than 3/8 inches in diameter and shall be either integral with the box or of the type which is inserted and supported from the back of the box. In no case will the support of a fixture be dependent upon bolts holding the stud to the box.
- 2. Outlet boxes for concealed work shall be arranged and located so that tile, where required, may be cut in straight lines to fit closely around the boxes, and so placed that the cover or device plate shall fit flush to the finished wall surface.
- 3. The exteriors of exposed outlet boxes shall be field painted, where required, in accordance with Section 09850, Painting.

B. Junction and Pull Boxes

- 1. All junction boxes and pull boxes shall be solidly attached to structural members prior to installation of conduit and set true and plumb. Wooden plugs are not permitted for securing boxes to concrete. Sidewalk-type boxes shall be cast into concrete structures and shall be flush with concrete services after installation.
- 2. Where control wires must be interconnected in a junction box, terminal strips, consisting of an adequate number of screw type terminals shall be installed. Current carrying parts of the terminal blocks shall be of ample capacity to carry the full load current of the circuits connected. Approximately 20 percent of the total amount of terminals provided shall consist of spare terminals. Terminals shall be lettered and/or numbered to conform with the wiring diagrams.
- 3. All junction boxes and pull boxes shall have identifying nameplates attached, which when installed on sidewalk type boxes shall not extend above the surrounding concrete slabs. All boxes shall be indicated and identified on the as-built drawings.

- END OF SECTION -

SECTION 16141

WIRING DEVICES

PART 1 -- GENERAL

1.01 THE REQUIREMENT

- A. The CONTRACTOR shall furnish and install all switches and receptacles for lighting and miscellaneous power applications of the type and at the locations as specified herein and as shown on the Drawings.
- B. All switches and receptacles shall be furnished and installed in outlet boxes as specified in Section 16130, Boxes.
- C. Reference Section 16000, Basic Electrical Requirements.

1.02 TESTING

- A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:
 - 1. Witnessed Shop Tests
 - a. None required.
 - 2. Field Tests
 - a. All field testing shall be done in accordance with the General Conditions, Division 1, and Section 16000, Basic Electrical Requirements.

1.03 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the CONTRACTOR shall obtain from the equipment manufacturer and submit shop drawings. Each submittal shall be identified by the applicable specification section.

1.04 SHOP DRAWINGS

- A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.
- B. Partial, incomplete, or illegible submittals will be returned to the CONTRACTOR without review for resubmittal.
- C. Shop drawings shall include, but not be limited to:
 - 1. Product data sheets.

1.05 SUPPLIES AND SPARE PARTS

- A. The CONTRACTOR shall furnish 10% (minimum of 1) spare of each receptacle, switch, and plug furnished and installed for this project.
- B. Spare parts lists, included with the shop drawing submittal, shall indicate specific sizes, quantities, and part numbers of the items to be furnished. Terms such as "1 lot of packing material" are not acceptable.
- C. Parts shall be completely identified with a numerical system to facilitate parts inventory control and stocking. Each part shall be properly identified by a separate number. Those parts which are identical for more than one size shall have the same parts number.

1.06 IDENTIFICATION

- A. Each switch and receptacle shall be identified with the equipment item number, manufacturer's name or trademark, and such other information as the manufacturer may consider necessary, or as specified, for complete identification.

PART 2 -- PRODUCTS

2.01 MANUFACTURERS

- A. The equipment covered by these Specifications is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.
- B. The CONTRACTOR shall use the products of a single manufacturer for each type of wiring device.
- C. The CONTRACTOR shall use the products of a single manufacturer for all device plates. Plate variations are allowed for the following devices:
 - 1. Where the selected plate manufacturer does not manufacture a suitable finish plate.
 - 2. For heavy-duty receptacles rated at more than 30A.
 - 3. Where non-standard plates are required, specified, or shown.
- D. The CONTRACTOR shall furnish and install all wiring devices and device plates. Wiring devices as listed herein are intended to indicate type, function, and quality of the products.
- E. The receptacles, switches, device plates, and other appurtenances shall comply with the requirements of these Specifications. Receptacles installed in toilet, locker, and bathrooms shall be of ground fault interrupter type to meet the minimum NEC

requirements. Ground fault circuit interrupter receptacles shall also be furnished and installed as specified herein, indicated on the Drawings, and required by the NEC.

- F. The CONTRACTOR shall provide specification grade devices which shall be as manufactured by Appleton, Crouse-Hinds, Leviton, Harvey Hubbell Co., General Electric Company, Bryant Electric Company, Pass & Seymour, or equal.

2.02 WIRING DEVICES

- A. Wiring devices shall be in accordance with the following for nonhazardous areas:

1. Wall Switches, Single Pole, 20 A, 120-277V equivalent to Hubbell No. 1221, Pass & Seymour No. 20AC1, Leviton equivalent, or equal. Switches rated 30 A, 120-277V shall be Leviton 3031, Hubbell equivalent, Pass & Seymour equivalent, or equal.
2. Wall Switches, Double Pole, 20 A, 120-277V equivalent to Hubbell No. 1222, Pass & Seymour No. 20AC2, Leviton equivalent, or equal. Switches rated 30 A, 120-277V shall be Leviton 3032, Hubbell equivalent, Pass & Seymour equivalent, or equal.
3. Wall Switches, Three-Way, 20 A, 120-277V equivalent to Hubbell No. 1223, Pass & Seymour No. 20AC3, Leviton equivalent, or equal. Switches rated 30 A, 120-277V shall be Leviton 3033, Hubbell equivalent, Pass & Seymour equivalent, or equal.
4. Wall Switches, Four-Way, 20 A, 120-277V equivalent to Hubbell No. 1224, Pass & Seymour No. 20AC4, Leviton equivalent, or equal.
5. Convenience Receptacles 20 A, 125V, duplex polarized with grounding connection equivalent to Hubbell No. 5362, Pass & Seymour equivalent, Leviton equivalent, or equal.
6. Hubbell Cat. No. GF-5362, Pass & Seymour equivalent, Leviton equivalent, or equal, for 20A, 120V, duplex, ground fault circuit interrupting type.

- B. Special Purpose Receptacles shall be rated to carry, at least where required the full load amperes and voltage of the unit connected thereto. These receptacles shall be provided with grounding poles and shall be equivalent to the following:

1. Hubbell Cat. No. HBL-5661, Pass & Seymour No. 5871, Leviton equivalent, or equal, for 20A, 250VAC, 1-phase service.
2. Hubbell Cat. No. HBL-9330, Pass & Seymour No. 3801, Leviton equivalent, or equal, for 30A, 250VAC, 1-phase service.
3. Hubbell Cat. No. 9430, Pass & Seymour No. 5740, Leviton equivalent, or equal, for 30A, 208/120V, 3-phase service.
4. Hubbell Cat. No. 9450, Pass & Seymour No. 5750, Leviton equivalent, or equal, for 50A, 208/120V, 3-phase service.

5. Hubbell Cat. No. 9460, Pass & Seymour No. 5760, Leviton equivalent, or equal, for 60A, 208/120V, 3-phase service.
6. Hubbell Cat. No. 9330, Pass & Seymour No. 5930, Leviton equivalent, or equal, for 30A, 208V, single-phase service.
7. Hubbell Cat. No. 9315, Pass & Seymour equivalent, Leviton equivalent, or equal, for 30A, 277V, single-phase service.
8. Hubbell Cat. No. 23CM10, Pass & Seymour equivalent, Leviton equivalent, or equal, for 20A, single, 125V, polarized with grounding connection, twist lock type. Matching plug shall be Hubbell Cat. No. 23CM11, Pass & Seymour equivalent, Leviton equivalent, or equal.
9. Crouse-Hinds "Arktite" Series, Appleton equivalent, Killark equivalent, or equal, 30A, 3P, 600 Volt, twist lock, weatherproof, power receptacle and box with matching plug.

C. For hazardous areas the following shall be provided:

1. Wall Switches, single pole, 20 A, 120 V equivalent to Crouse Hinds Cat. No. EFD3591 or EFDC3591 (as required); Appleton No. EDS175F1 or EDSC175F1, Killark equivalent, or equal.
2. Convenience Receptacles 20 A, 120-250 VAC, 2 wire, 3 pole equivalent to Crouse Hinds Cat. No. CPS152-201, Appleton No. CPE1-2375, Killark equivalent, or equal.

D. Plugs for hazardous and non-hazardous receptacles shall be provided:

1. One mating plug of the same or better grade for each 10 convenience receptacles, minimum of 2 each.
2. Plugs and respective cable shall be provided for equipment furnished under other Divisions (steam cleaners, welders, etc.) as necessary.

2.03 DEVICE PLATES

- A. Wall plates with gaskets for flush-mounted receptacles and switches shall be made of Type 304 stainless steel, not less than 0.040 of an inch thick, with beveled edges and milled on the rear so as to lie flat against the wall. Wall plates shall be equivalent to Hubbell Series 9600, Pass & Seymour series 93000, Leviton equivalent, or equal.
- B. Device plates for weatherproof and watertight installations shall be Appleton Type FSR, Crouse-Hinds #DS185, or equal for wall switches and Appleton Type FSK, Crouse-Hinds #WLRD, or equal for convenience receptacles. "In-use" weatherproof covers shall be rugged, die-cast aluminum as manufactured by Thomas & Betts "Red Dot," or equal.

2.04 PLUGS

- A. The CONTRACTOR shall furnish suitable plugs with equipment furnished under the respective Contract. Plugs shall be black rubber or plastic. For waterproof receptacles, the plugs shall be similar in construction to the receptacles and shall be encased in corrosion resistant yellow housing provided with clamping nuts and stuffing gland cable outlets.

2.05 PROCESS INSTRUMENTS

- A. The CONTRACTOR shall furnish and install a local disconnect switch at each process instrument (e.g., level transmitter, flow transmitter, analytical instrument etc.) to disconnect the 120VAC power supply to the instrument. The device shall be a NSSC series manual motor starting switch without overload protection as manufactured by Crouse-Hinds, Appleton equivalent, or equal. For hazardous locations, the device shall be a front operated general use snap switch mounted in an EFS enclosure as manufactured by Crouse-Hinds, Appleton equivalent, or equal.

PART 3 -- EXECUTION

3.01 INSTALLATION

- A. Switch boxes shall be of unit construction and of sizes as required to adequately house the number of switches required. No sectional type switch boxes shall be permitted.
- B. Where more than one switch occurs at one point, gang plates shall be used.
- C. All device plates shall be set true and plumb, and shall fit tightly against the finished wall surfaces and outlet boxes.
- D. All devices shall be flush-mounted in finished areas, unless otherwise noted. The CONTRACTOR shall determine the proper position of every outlet, and relocate any outlet without additional cost to the OWNER if same is incorrectly or improperly located. The ENGINEER reserves the right to change the location of any outlet or connecting equipment up to the time of roughing in without additional cost to the OWNER, provided conduit runs are not increased by more than 10 feet.
- E. In all areas where thermal or acoustic insulation is applied to the ceiling or walls, outlet boxes shall be set to finish flush with the finished surface of the insulation.
- F. When indicated height would place any of the equipment at an unsuitable location such as at a molding or break in wall finish, the ENGINEER shall determine final location.
- G. For the below-named items mounting heights from finish floor, or finish grade to top is applicable. Mounting heights shall be as follows, unless otherwise specified herein, indicated on the Drawings, or required by the Americans with Disability Act (ADA):
 - 1. Single-pole light switches, 48 inches.
 - 2. Duplex receptacles in dry areas, 16 inches

3. Duplex receptacles in pump rooms, 48 inches

3.02 CIRCUITING

- A. Convenience receptacles shall be grouped on circuits separate from the lighting circuits. A maximum of eight (8) convenience outlets are permitted per 20A, 120V circuit.

- END OF SECTION –

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SECTION 16170
GROUNDING AND BONDING

PART 1 -- GENERAL

1.01 THE REQUIREMENT

- A. The CONTRACTOR shall furnish and install grounding systems complete in accordance with the minimum requirements established by Article 250 of the NEC. Article 250 of the NEC shall be considered as a minimum requirement for compliance with this Specification.
- B. Grounding of all instrumentation and control systems shall be furnished and installed in accordance with the manufacturer/system requirements and IEEE 1100-92, Powering and Grounding of Sensitive Electronic Equipment. Conflicts shall be promptly brought to the attention of the ENGINEER.
- C. In addition to the NEC requirements, building structural steel columns shall be permanently and effectively grounded:
- D. Reference Section 16000, Basic Electrical Requirements.

1.02 TESTING

- A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:
 - 1. Witnessed Shop Tests
 - a. None required.
 - 2. Field Tests
 - a. Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 1, and Section 16000, Basic Electrical Requirements.

1.03 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the CONTRACTOR shall obtain from the equipment manufacturer and submit the following:
 - 1. Shop Drawings
 - 2. Reports of certified field tests.
- B. Each submittal shall be identified by the applicable specification section.

1.04 SHOP DRAWINGS

- A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.
- B. Partial, incomplete, or illegible submittals will be returned to the CONTRACTOR without review for resubmittal.
- C. Shop drawings shall include but not be limited to:
 - 1. Equipment specifications and product data sheets.
 - 2. Drawings and written description of how the CONTRACTOR intends to furnish and install the grounding system.

PART 2 -- PRODUCTS

2.01 MANUFACTURERS

- A. The equipment covered by these specifications shall be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

2.02 GROUND RODS AND GRID

- A. Ground rods shall be rolled to a commercially round shape from a welded copper-clad steel manufactured by the molten-welding process or by the electro-formed process (molecularly bonded). They shall have an ultimate tensile strength of 75,000 pounds per square inch (psi) and an elastic limit of 49,000 psi. The rods shall be not less than 3/4 inch in diameter by 10 feet in length; and the proportion of copper shall be uniform throughout the length of the rod. The copper shall have a minimum wall thickness of 0.010 inch at any point on the rod.
- B. The maximum resistance to ground of a driven ground rod shall not exceed 5 ohms under normally dry conditions. Where the resistance obtained with one (1) ground rod exceeds 5 ohms, additional ground rods shall be installed not less than 6 feet on centers. Except where specifically indicated otherwise, all exposed non current-carrying metallic parts of electrical equipment, metallic raceway systems, grounding conductors in nonmetallic raceways and neutral conductors of wiring systems shall be grounded.
- C. The ground connection shall be made at the main service equipment and shall be extended to the point of entrance of the metallic water service. Connection to the water pipe shall be made by a suitable ground clamp or lug connection to a plugged tee. If flanged pipes are encountered, connection shall be made with the lug bolted to the street side of the flanged connection. If there is not suitable metallic water service to the facility, the ground connection shall be made to the driven ground rods on the exterior of the building.

- D. Where ground fault protection is employed, care shall be taken so that the connection of the ground and neutral does not interfere with the correct operation of the ground fault protection system.

2.03 FITTINGS

- A. Grounding connections to equipment shall be bolted. Cable end connections may be made by use of the crucible weld process or bolted type connectors. Bolted type connectors for this application shall consist of corrosion resistant copper alloy with silicone bronze bolts, nuts and lockwashers which are designed for this purpose.

2.04 GROUNDING CONDUCTORS

- A. A green, insulated equipment grounding conductor, which shall be separate from the electrical system neutral conductor, shall be furnished and installed for all circuits. Equipment grounding conductors shall be furnished and installed in all conduits. Use of conduits as the NEC required equipment grounding conductor is not acceptable.

2.05 EQUIPMENT GROUNDS

- A. Equipment grounds shall be solid and continuous from a connection at earth to all distribution panelboards. Ground connections at panelboards, outlets, equipment, and apparatus shall be made in an approved and permanent manner.

PART 3 -- EXECUTION

3.01 INSTALLATION

- A. Metal surfaces where grounding connections are to be made shall be clean and dry. Steel surfaces shall be ground or filed to remove all scale, rust, grease, and dirt. Copper and galvanized steel shall be cleaned with emery cloth to remove oxide before making connections.
- B. Ground Grid
 - 1. A main ground grid shall be provided for each structure and interconnecting structure grids consisting of driven ground rods. The ground rods shall be driven deep enough to obtain a ground resistance of not more than 5 ohms and shall be interconnected by the use of copper cable bus, welded to the rods by the crucible weld process. The grounding cables shall be installed after the excavations for the building have been completed and prior to the pouring of concrete for the footings, mats, etc. Copper "pigtailes" shall be connected to the ground system and shall enter the buildings and structure from the outside and shall be connected to steel structures, and equipment as described in this Section and as required to provide a complete grounding system.
 - 2. Grounding conductors shall be continuous between points of connection; splices shall not be permitted.

3. Where conductors are exposed and subject to damage from personnel, traffic, etc., conductors shall be installed in metal raceway. The raceway shall be bonded to the grounding system.
4. Connections to ground rods shall be exposed to permit maintenance and inspection for continuity and effectiveness of grounding system.
5. Where subsurface conditions do not permit use of driven ground rods to obtain proper ground resistance, rods shall be installed in a trench or plate electrodes shall be provided, as applicable and necessary to obtain proper values of resistance.

C. Raceways

1. Conduit which enters equipment such as switchgear, motor control centers, transformers, panelboards, variable frequency drives, instrument and control panels, and similar equipment shall be bonded to the ground bus or ground lug, where provided, and as otherwise required by the NEC.

- END OF SECTION -

SECTION 16190
SUPPORTING DEVICES

PART 1 -- GENERAL

1.01 THE REQUIREMENT

- A. The CONTRACTOR shall furnish and install structural steel supports for mounting and installing all electrical, lighting, alarm systems, instrumentation, and communications equipment furnished under this Contract.
- B. Equipment shall be installed strictly in accordance with recommendations of the manufacturer and best practices of the trade resulting in a complete, operable, and safe installation. The CONTRACTOR shall obtain written installation manuals from the equipment manufacturer prior to installation.
- C. Reference Section 16000, Basic Electrical Requirements.

1.02 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the CONTRACTOR shall obtain from the equipment manufacturer and submit shop drawings. Each submittal shall be identified by the applicable Specification section.

1.03 SHOP DRAWINGS

- A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.
- B. Partial, incomplete, or illegible submittals will be returned to the CONTRACTOR without review for resubmittal.
- C. Shop drawings shall include but not be limited to:
 - 1. Equipment specifications and product data sheets.
 - 2. Complete assembly, layout, installation, and foundation drawings with clearly marked dimensions.

PART 2 -- PRODUCTS

2.01 MANUFACTURERS

- A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be

designed, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

2.02 MATERIALS

- A. Materials used in accordance with this Section shall be as specified herein.

PART 3 -- EXECUTION

3.01 INSTALLATION

- A. Concrete or Masonry Inserts

1. The CONTRACTOR shall be responsible for the furnishing and installation of all conduit sleeves, anchor bolts, masonry inserts, and similar devices required for installation of equipment furnished under this Contract.
2. If a time delay for the arrival of any special inserts or equipment drawings, etc. occurs, the CONTRACTOR may, if permitted by the JEA, make arrangements for providing approved recesses and openings in the concrete or masonry and, upon subsequent installation, the CONTRACTOR shall be responsible for filling in such recesses and openings. Any additional costs that may be incurred by this procedure shall be borne by the CONTRACTOR.
3. The CONTRACTOR shall furnish leveling steel channels for all switchgear, switchboards, motor control centers, and similar equipment. The leveling steel channels shall be provided for installation in the equipment supporting pads. Coordination of the installation of these channels with the concrete pad is essential and required. Pad height shall be as required to maintain coverage of the reinforcement bars while not exceeding the maximum mounting heights requirements of the NEC.

- B. Support Fastening and Locations

1. All equipment fastenings to columns, steel beams, and trusses shall be by beam clamps or welded. No holes shall be drilled in the steel. Where supports or hangers are required for heavy electrical equipment units exceeding fifty pounds, a registered professional engineer shall check the steel. Where required, additional sections shall be provided for a safe installation.
2. All holes in hung ceilings for support rods, conduits, and other equipment shall be made adjacent to bars where possible, to facilitate removal of ceiling panels.
3. For interior dry areas, a bracket and channel type support of hot dipped galvanized steel construction shall be provided wherever required for the support of starters, switches, panels, and miscellaneous equipment.
4. For outdoor service or in indoor damp/wet process areas, the support system shall be made of hot dipped galvanized steel. The materials of construction shall

be coordinated with the process/chemical area in which the support system will be installed.

5. All hardware (bolts, nuts, washers, etc.) shall be Type 316 stainless steel.
6. All supports shall be rigidly bolted together and braced to make a substantial supporting framework. Where possible, control equipment shall be grouped together and mounted on a single framework. Wherever this occurs, a provision shall be made for ready access to the wiring for connections to the equipment by means of boxes with screw covers.
7. Aluminum support members shall not be installed in direct contact with concrete. Stainless steel or non-metallic "spacers" shall be used to prevent contact of aluminum with concrete.
8. Actual designs for supporting framework should take the nature of a picture frame of channels and bracket with a plate for mounting the components. The CONTRACTOR is responsible for the design of supporting structure; he shall submit design details to the ENGINEER for acceptance before proceeding with the fabrication.
9. Wherever dissimilar metals come into contact, the CONTRACTOR shall isolate these metals as required with neoprene washers, nine (9) mil polyethylene tape, or gaskets.

- END OF SECTION -

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SECTION 16440
DISCONNECT SWITCHES

PART 1 -- GENERAL

1.01 THE REQUIREMENT

- A. The CONTRACTOR shall furnish and install separately mounted, individual disconnect switches as specified herein and indicated on the Drawings.
- B. Reference Section 16000, Basic Electrical Requirements.

1.02 TESTING

- A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:
 - 1. Witnessed Shop Tests
 - a. None required.
 - 2. Field Tests
 - a. Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 1, and Section 16000, Basic Electrical Requirements.

1.03 SUBMITTALS

- A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the CONTRACTOR shall obtain from the equipment manufacturer and submit the following:
 - 1. Shop Drawings
 - 2. Spare Parts List
- B. Each submittal shall be identified by the applicable specification section.

1.04 SHOP DRAWINGS

- A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.
- B. Partial, incomplete or illegible submittals will be returned to the CONTRACTOR without review for resubmittal.

- C. Shop drawings shall include but not be limited to:
 - 1. Product data sheets.
 - 2. Complete layout and installation drawings with clearly marked dimensions for each type/size/rating of disconnect switch.
 - 3. Assembled weight of each unit.
- D. The shop drawing information shall be complete and organized in such a way that the ENGINEER can determine if the requirements of these Specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items that the CONTRACTOR intends to provide are acceptable and shall be submitted.

1.05 TOOLS, SUPPLIES, AND SPARE PARTS

- A. The equipment shall be furnished with all special tools necessary to disassemble, service, repair, and adjust the equipment, and with all spare parts as recommended by the equipment manufacturer.
- B. One complete set of spare fuses for each ampere rating installed shall be furnished and delivered to the OWNER at the time of final inspection.
- C. Spare parts lists, included with the shop drawing submittal, shall indicate specific sizes, quantities, and part numbers of the items to be furnished. Terms such as "1 lot of packing material" are not acceptable. Spares shall be supplied for startup services only.
- D. Parts shall be completely identified with a numerical system to facilitate parts inventory control and stocking. Each part shall be properly identified by a separate number. Those parts which are identical for more than one size, shall have the same parts number.

1.06 IDENTIFICATION

- A. Each equipment item shall be identified with a nameplate. The nameplate shall be engraved indicating the circuit number and equipment name with which it is associated. Equipment identification shall be in accordance with Section 16195, Electrical - Identification.

PART 2 -- PRODUCTS

2.01 MANUFACTURERS

- A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

- B. Switches shall be manufactured by Square D Company, Cutler-Hammer, General Electric Company, or equal.

2.02 DISCONNECT SWITCHES

- A. Disconnect switches shall be heavy-duty type and/or as specified in these Specifications. Switches shall be furnished and installed as shown on the Drawings and as required by the NEC. Handles shall be lockable.
- B. Switches shall be NEMA Type HD, single-throw, externally operated, fused or non-fused as required. Switches of the poles, voltage, and ampere ratings shown shall be furnished in NEMA 1A (gasketed) enclosures in indoor dry areas, and in NEMA 4X Type 304 stainless steel enclosures for damp/wet indoor process areas. Enclosures for outdoor applications shall be NEMA 4X Type 316 stainless steel. Switches located in hazardous areas shall be suitable for the Class, Division, and Group to suit the application.
- C. Disconnect switches shall be quick-make, quick-break and with an interlocked cover which cannot be opened when switch is in the "ON" position and capable of being locked in the "OPEN" position.
- D. A complete set of fuses for all switches shall be furnished and installed as required. Time-current characteristic curves of fuses serving motors or connected in series with circuit breakers shall be coordinated for proper operation. Fuses shall have voltage rating not less than the circuit voltage.

PART 3 -- EXECUTION

3.01 INSTALLATION

- A. All disconnect switches to be mounted five (5) feet above the floor, at the equipment height where appropriate, or where shown otherwise.
- B. The CONTRACTOR shall furnish and install fuses of various types as required with the continuous ampere ratings as required or shown on the Drawings.

- END OF SECTION -

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