

SECTION 16013- ELECTRICAL

PART 1 GENERAL

1.01 DESCRIPTION

- A. The Work of Division 16 – ELECTRICAL WORK is indicated on drawings/sheets numbered: E-1 through E-9.

1.02 EXENT OF WORK

- A. The work to be done under this Section consists of furnishing all materials, labor, tools and equipment, and performing all operations necessary to complete all electrical systems, as shown on the Drawings and as specified herein.
- B. The work shall include, but not be limited to the following items:
1. Demolition work as shown on the drawing.
 2. Modification of the power distribution system as shown on the drawings.
 3. Installing and wiring new Biofilter Blower Fan power and Control system.
 4. Installing and wiring new exhaust fans 30 & 31 as well as the heat trace systems as shown in the drawings.
 5. Grounding system complete as required by the New Hampshire Electrical Code and/or as shown on the Drawings.
 6. Heat trace system shall be installed and tested prior to the installation of the piping insulation.
 7. Grounding system complete as required by the New Hampshire Electrical Code and/ or as shown on the Drawings.

1.03 WORK NOT INCLUDED

- A. The following items of work are not specified under this Section of the Specifications, but are specified under other Sections, or are to be furnished by others, except that all wiring shall be done under this Section:
1. Furnishing and installing, VFD's, motors and solenoid valves; however all wiring for them shall be done under this Section (Electrical).

1.04 DRAWINGS

- A. The Drawings, which constitute an integral part of this contract, shall serve as the working drawings. They indicate the general layout of the complete electrical system or systems, arrangement of branch circuits, outlets, switches, controls, fixtures and other work.
- B. Field verification of scale dimensions on the Drawings is directed, since actual locations, distances and levels will be governed by actual field conditions.
- C. The Contractor shall also review mechanical Drawings, shop drawings and all Specifications, and shall adjust his work to conform to all conditions indicated thereon.
- D. The Contractor shall be responsible for coordinating dimensions, for mounting channels, etc., for equipment purchased by him.

1.05 STANDARDS, CODES AND REGULATIONS

- A. The Contractor shall furnish all materials in accordance with and perform all work required so that the materials and installation shall conform to the following standards, codes and regulations:
 - 1. National Fire Protection Association NFPA 70 New Hampshire Electrical Code.
 - 2. Underwriters' Laboratories, Inc.- Standards for Cabinets and Boxes, Service Equipment, and Rubber Covered Wires and Cables.
 - 3. American National Standards Institute - Standards.
 - 4. National Electrical Manufacturing Association Standards.
 - 5. All applicable State and local codes or ordinances and requirements of the Authority Having Jurisdiction.
 - 6. Insulated Power Cable Engineers Association Standards.
 - 7. American Society for Testing and Materials Standards.
 - 8. National Fire Protection Association-Pamphlet No. 31.
 - 9. Department of Public Safety regulations.
 - 10. Occupational Safety and Health Regulations.

11. Institute of Electronic and Electrical Engineers Standards.

12. ANSI C-2 National Electrical Safety Code

- B. In the event that codes require a change in the material design, any such changes shall be submitted to the Owner for approval before proceeding with the work.

1.06 APPROVAL OF EQUIPMENT AND MATERIALS

- A. Shop drawings shall be submitted in accordance with Section 01300 - SUBMITTALS. The shop drawings shall include catalog numbers, cuts, diagrams, detailed dimensioned shop drawings of equipment, brochures of lighting fixtures, wiring diagrams as required, drawings, samples as requested, and such other pertinent descriptive ratings and data as may be required by the Engineer. No consideration will be given to partial lists submitted from time to time on items, which are interdependent for proper operation, coordination, etc. Approval of materials will be based on manufacturer's published ratings. Any equipment, fixtures and materials listed which, in the opinion of the Engineer, are not in accordance with the Specification requirements, or requirements shown on the Drawings, will be rejected and others shall be submitted. Equipment and materials, which are installed by the Contractor without first having been approved by the Engineer, shall be removed if installed and/or removed from the work site when so instructed by the Engineer. No payment will be made for unapproved equipment or material or for its installation if the Contractor is ordered to remove such equipment and material.

1.07 SLEEVES, INSERTS AND OPENINGS

- A. The Contractor shall lay out and install his work in advance of pouring concrete floors, walls and ceilings. The Contractor shall furnish and install all sleeves or openings through floors or walls required for passage of all conduits, pipes or ducts to be installed by him and if repairs are required due to errors and omissions or tardy installation, he shall have all patching and restoration to floors, ceilings or walls, including necessary painting, done by the trades involved after his work is installed and completed at no additional cost to the Owner. Sleeves through floors other than base slabs shall be made of galvanized sheet steel or PVC rigidly supported and suitably packed to prevent ingress of wet concrete. All conduits passing underground into basement areas shall be provided with conduit cable seals similar to O.Z. Company, Type CSB, Spring City Electrical Manufacturing Type WEC, Metraflex Co. "Metra Seals" or equal. The Contractor shall furnish and install all inserts and hangers required to support fixture channels, conduits, pull boxes, etc. If the sleeves, etc., are improperly installed, the Contractor shall do all necessary cutting and patching to rectify the errors at no additional cost to the Owner. The Contractor when installing conduits thru existing floors and walls shall core drill holes as required and install appropriate seals. Double mechanical

seals shall be used on penetrations thru outside walls and interior walls between areas exposed to potential hazardous or explosive gases.

1.08 MATERIAL SUBSTITUTION

- A. Should the Contractor desire to substitute other makes of materials, apparatus or appliances than those mentioned herein or shown on the Drawings, he shall do so in the following manner:
 - 1. Submit a separate alternate proposal and provide a list of the proposed substitutions, manufacturer, brand name, catalog number, etc. and state what difference each will make (addition, deduction, no change) in the contract price. He shall also submit data and certified independent test, if requested, showing the proposed substitutions are equal to the specified types.
 - 2. Where such substitutions alter the design or space requirements indicated on the Drawings, the Contractor shall include all items of cost for the revised design and construction, including cost of all allied trades involved, and at no additional cost to the Owner.
 - 3. If requested by the Engineer, the Contractor shall furnish and deliver samples of both the specified and proposed substitute items to the Engineer's office at no additional cost.
 - 4. If so requested by the Engineer, the Contractor shall submit data showing quoted prices of specified and proposed substitute items. Acceptance or rejection of proposed substitute items will be the sole responsibility of the Engineer. The Contractor shall accept the Engineer's decision as final.

1.09 SUPERVISION

- A. The Contractor shall personally or through an authorized and competent representative constantly supervise the work from its beginning to its completion and acceptance. He shall, so far as possible, keep the same foreman and workmen on the work from its commencement to its completion.

1.10 COOPERATION WITH OTHER TRADES

- A. The Contractor before starting work shall confer with all subcontractors interested in the location of pipes, equipment, or any other apparatus or fixtures to be installed by them and shall select his location so as not to interfere with the work and rights of the other trades. All differences or conflicting conditions shall be brought to the attention of the Engineer for adjustment before commencing work, and any such work or materials placed in position in violation of this clause shall be readjusted at the expense of the Contractor.

- B. The work shall be so performed that the program of the entire project, including all other trades, will not be interfered with. Materials and equipment shall be installed as fast as conditions of the building permit and shall be installed promptly when and as directed.
 - C. It shall be the Contractor's responsibility to check the Drawings and Specifications of the other trades for their requirements for electrical work and to accomplish the electrical work as approved by the Engineer.
 - D. The Contractor shall not scale Drawings for measurements but shall verify at the building all levels and measurements necessary for complete fabrication, assembling, and installation of his work. Minor details of the work not specifically shown on the Drawings shall be ascertained by the Contractor at the site of the work and shall be accomplished by him to make a workable system or systems in accordance with the intent of these Specifications.
1. The Contractor shall, before presenting his proposal, visit the site and acquaint himself with all aspects of the work. He shall become familiar with the conditions and circumstances under which he will be required to operate.
 2. Service interruptions and all other work which will interfere with plant functions shall be made at specific times designated by the Engineer. No extras will be allowed for work that has to be done outside of regular working hours or for any work necessitated by unfamiliarity with existing conditions which could and should have been ascertained by the Contractor before presenting his proposal.

1.11 DEMOLITION

- A. Survey the existing electrical systems and equipment identified for removal with representatives from the other trades prior to performing any demolition work. Identify all conduit and equipment to be removed with tags or paint.
- B. Where a piece of equipment is to be removed all associated ancillary components (e.g. solenoid valves, pressure switches, etc) and associated wiring and conduit shall also be removed.
- C. Equipment scheduled to be turned over to the Owner shall be carefully disconnected, removed and delivered to the Owner.
- D. Remove electrical work associated with equipment scheduled for demolition except those portions indicated to remain or be reused.
- E. Unless otherwise specifically noted, remove unused exposed conduit and support systems back to point of concealment including abandoned conduit above acces-

sible ceiling finishes. Remove unused wiring back to source (or nearest point of usage). Seal conduits at the point of termination.

- F. Disconnect and remove abandoned disconnect switches, control stations, distribution equipment, etc.
- G. Repair adjacent construction and finishes damaged during demolition and extension work.
- H. Where electrical systems pass through the demolition areas to serve other portions of the premises, they shall remain or be suitably relocated and the system restored to normal operation.
- I. The electrical and process equipment to be removed or relocated under this contract has been identified on the Drawings. The removal and or relocation of existing conduit, wire and equipment have not been detailed on the Drawings. Survey the affected equipment and building areas before submitting bid proposal.
- J. Trace out existing wiring that is to be relocated, or removed and perform the relocation or removal work as required for a complete operating and safe system.
- K. Remove exposed conduits, pull boxes and hangers made obsolete by the alterations, unless specifically designated to remain.
- L. All equipment, materials, controls, motor starters, branch and feeder breakers, wiring, raceways, etc, furnished and installed to temporarily keep circuits energized shall be removed when the permanent installation is fully operational.

1.12 WARRANTY

- A. For a period of 12 months from the date of substantial completion, the Contractor warrants to the Owner that the equipment specified under this section of the Specifications conform to these specifications and are free from defects in materials and workmanship. The Contractor shall repair or replace, at the sole option of and at no cost to the Owner, any work found to be defective within said warranty period. Such repair or replacement shall include the cost of removal and installation.
- B. The electrical system or systems, together with the component units as included in this Section of the Specifications, shall be warranted for a period of one year from the date of final acceptance thereof against defective materials and workmanship. Upon receipt of notice from the Owner or Engineer of failure of any parts of the warranted equipment during the guarantee period, the affected part or parts shall be replaced promptly with new parts by and at the expense of the Contractor.

- C. 5th Harmonic Tuned Shunt Filter
 - 1. Contractor's Warranty. For a period of 2 years from the date of substantial completion, the Contractor warrants to the Owner that the capacitor cells conform to these specifications and is free from defects in materials and workmanship. The Contractor shall repair or replace, at the sole option of and at no cost to the Owner, any work found to be defective within said warranty period. Such repair or replacement shall include the cost of removal and reinstallation.
 - 2. Manufacturer's Warranty. The Contractor shall obtain from the manufacturer its warranty that the capacitor cells will be free from defects in materials and workmanship for a period of 2 years following substantial completion. Said warranty, containing no exclusions or limitations, shall be in a form acceptable to, and for the benefit of, the Owner and shall be submitted by the Contractor as a condition of final payment.

PART 2 PRODUCTS

2.01 GENERAL

- A. All equipment and materials furnished by the Contractor shall be new and first grade, and as approved by the Underwriters' Laboratories, Inc., and/or by other standards mentioned in these Specifications. The materials to be furnished under this Specification shall be the standard products of manufacturers regularly engaged in the production of such equipment and shall be of the latest standard design. Equipment and materials shall be of the type and quality listed below.

2.02 WIRE AND CABLE

- A. Wires and cables shall meet applicable requirements of NFPA 70 and UL for types of insulation, jacket, and conductor specified or indicated. Wire and cable shall be new and shall have the size, grade of insulation, voltage and manufacturer's name permanently marked on the outer covering at regular intervals and shall be delivered in complete coils or reels with identifying size, type and insulation tags. Wire and cable shall be suitably protected from weather and damage during storage and handling, and shall be in first-class condition when installed.
- B. Low voltage conductors (600 volts). Conductors shall be soft-drawn annealed copper with heat- and moisture-resistant insulation, for 75 or 90 degrees C. service, type XHHW-2 conforming to UL 44. Minimum wire size shall be No. 12 AWG. Conductors No. 10 and smaller shall be solid. Wire and cable shall be factory color coded with a separate color for each phase and neutral used consistency throughout. Colors shall be black, red, blue and white for the 120/208 volt system. Conductors shall be as manufactured by Cablec Corporation, Okonite Company, American Insulated Wire, Southwire Company or equal.

- C. Grounding Cable. Grounding cable installed in the raceways with circuit cables shall be single conductor, stranded, soft-drawn annealed copper, 600 volt, type XHHW-2 conforming to UL 83, colored green.
- D. Control, Status and Alarm Wire
 - 1. Wire shall be No.14 AWG NEC type THHN/THWN, stranded as manufactured by the Okonite Co.; Carol Cable Co. Inc.; Pirelli Cable Corp. or equal.
 - 2. Multi-conductor control cable, where shown on the Drawings, shall be stranded, No. 14 AWG, 600 Volt, polyvinyl chloride insulated, nylon jacket over insulation, polyvinyl chloride jacket overall, Type TC as manufactured by the Okonite Co.; Pirelli Cable Corp. or equal.

2.03 CONDUIT AND CONDUIT FITTINGS

- A. PVC coated rigid steel.
 - 1. PVC coated rigid steel shall have a 40-mil thick, bonded polyvinyl chloride coating on the exterior and a 2-mil urethane coating on the interior.
 - 2. All coated conduit shall conform to NEMA Standard RN-1.
 - 3. All conduit, prior to coating shall conform to Federal Specification WW-C-581, ANSI Standard C80.1, and to Underwriters' Laboratories, Inc. UL-6.
 - 4. The zinc surface of the conduit shall remain intact and undisturbed on both the inside and the outside of the conduit throughout the preparation and application processing. A polyvinyl chloride (PVC) coating shall be bonded to the galvanized outer surface of the conduit. The bond between the PVC coating and the conduit surface shall be greater than the tensile strength of the plastic. The thickness of the PVC coating shall be a minimum of 40 mils thick.
 - 5. A loose coupling shall be furnished with each length of conduit. A PVC coating shall be bonded to the outer surface of the coupling and a PVC sleeve equal to the outside diameter of the uncoated conduit shall extend beyond both ends of the coupling approximately one pipe diameter or 2 inches, whichever is smaller. The wall thickness of the coating on the coupling and the sleeve shall be at least as thick as the coating on the conduit. The coupling shall also have a urethane coating applied to the exterior, the interior and to the threads.
 - 6. A wall thickness of the coating on conduit bodies and fittings and the sleeve walls shall be identical to those on couplings in length and thickness. The covers on all conduit bodies shall be coated on both sides and shall be designed to be

completely interchangeable. The inside of conduit bodies shall have a nominal 2 mil urethane coating inside.

7. All coated material shall be installed and patched according to the manufacturer's recommended installation and patching instructions.
8. The conduit shall be shipped with thread protectors installed on both ends and the couplings boxed separately. Conduit threads shall be hot dipped galvanized and coated with urethane.
9. Clips and other fittings used with PVC coated conduit shall have factory applied urethane and PVC coatings.
10. A touch-up compound shall be provided for exposed threads and areas damaged during installation.
11. Conduit shall be as manufactured by Occidental Coatings Co., Robroy Industries, Perma-Cote Industries, or equal.

B. Galvanized Rigid Steel Conduit.

Rigid steel conduit shall be mild hot-dipped galvanized steel piping not less than 3/4-inch size. The galvanized coating of zinc shall be of uniform thickness both inside and outside, and to the threads of the conduit. The conduit shall be further protected by one or more of the following:

1. Electro-galvanized after hot-dipped galvanizing and/or
2. An alkaline cleaner bath and rinse and a chromic acid bath to form a film of zinc chromate over all and/or
3. A thin polyvinyl or a lacquer coating baked on the inside and outside of conduit.
4. Conduit protected solely by enamel, electro-galvanizing, or other processes, etc., will not be acceptable. Conduit shall also conform to the following specifications:
 - a. Federal Specification WW-C-581.
 - b. ANSI Standard C80.1.
 - c. ASTM Standard A 120.
 - d. Underwriters' Laboratories UL 6.

5. Conduit shall be as manufactured by Allied Tube and Conduit Corp., Wheatland Tube Co., Cal Conduit, or equal.
- C. Flexible. Flexible conduit installed in non-hazardous areas shall be steel liquid-tight type with a copper bonding wire conforming to Underwriters' Laboratories UL 360. Flexible conduit shall be as manufactured by Anaconda Metal Hose "Sealtite" Type UA, Electri-Flex Co. "Liquatite", Alflex "Ultratite" or equal. Liquid tight flexible metal conduit connectors shall have grounding ferrules, which when the compression nut is tightened assures collaring of the liquid tight conduit in such a way that the end of the ferrule pinches around the conduit. Connectors shall be as manufactured by Appleton Electric Co., Crouse Hinds Co., O.Z. Gedney or equal.
 - D. Conduit outlet bodies shall be cast, Appleton Electric Co. Form 35, Crouse-Hinds Co. Form 8, Killark O Series for pvc coated rigid steel conduit or equal. Conduit outlet bodies shall be rigid PVC for rigid PVC conduit.
 - E. Non Metallic Conduit and Fittings
 1. PVC conduit shall be rigid polyvinyl chloride schedule 40. Rigid PVC conduit up to trade sizes 3-1/2-in shall comply with NEMA TC-2 and UL/651 and shall be sunlight resistant, rated for use with 90 degree C conductors in exposed, direct burial or concrete encased applications. Underground utility duct, 4-in trade size and above, shall be high density polyethylene (HDPE) Schedule 40 conduit encased in concrete, rated for use with 90 degree C conductors and shall comply with NEMA TC-8 and ASTM F512.
 2. Connectors, couplings, fittings and ancillary materials shall be supplied by the conduit manufacturer.
 3. Acceptable manufacturers:
 - a. Carlon Corp.
 - b. Certained Corp.
 - c. Conux Pipe Systems, Inc.
 - d. Or equal.

2.04 RECEPTACLES

- A. Receptacles used in the division II, Class I, Group C &D structures shall be explosion proof, in NEMA 4X enclosure, 20 Amp, 125 Volt, polarized three-wire grounding nylon duplex type, with ground fault protection, as manufactured by Pass and Seymour, Hubbell, Bryant or equal. Receptacles shall comply with 2008 NEC Article 406.8.

- B. Duplex receptacles shall conform to UL 498 and NEMA WD 1 and shall be heavy duty, specification grade three-wire grounding type capable of admitting standard 2-pole or grounding type 3-pole caps. Receptacles shall be 15 ampere, 125 volt, Bryant, Hubbell, Arrow-Hart, Pass and Seymour, General Electric or equal, all Cat. No. 5262 with self-grounding feature.
- C. Weatherproof receptacles shall be polarized three-wire grounding nylon duplex type, Arrow Hart and Bryant No. 5262-CR, Pass and Seymour No. CR6200, General Electric No. 5262C or equal.

2.05 DEVICE PLATES AND COVERS

- A. Device covers for weatherproof switches and receptacles shall be as follows:
 - 1. Switch covers shall be fiberglass or cast nonferrous metal with neoprene gaskets.
 - 2. Receptacle covers shall be vertical mounting, standard depth, cast metal, weatherproof while-in-use in accordance with 2008 N.E.C. Article 406.8(B)1, and shall be T&B Red Dot "Code Keeper" Cat. No. CKMDV (for standard duplex) or CKMGV (for GFCI duplex), Teddico Cat. No. WT1010MC, TayMac Cat. No. MX3200, Cooper Cat. No. WIUMV-1, or equal.

2.06 OUTLET BOXES

- A. Surface mounted outlet boxes shall be cast, type FD for devices or type JB for fixtures or type SEH for junction boxes, etc. All surface mounted boxes for pvc coated rigid steel conduit shall be pvc coated and shall have threaded bosses or hubs, mounting flanges, and gasketed covers. Cast boxes shall be as manufactured by Crouse-Hinds, Appleton Electric Co., Killark Electric Co., or equal. Outlet boxes for rigid PVC conduit shall be rigid PVC.

2.07 PULL OR JUNCTION BOXES

- A. Junction or pull boxes installed indoors shall conform to UL 50 and shall be of code gauge galvanized sheet metal and of sufficient size to accommodate the size conduits and number of wires as required by the NEC. Box covers shall be fastened with stainless steel or brass screws. Junction boxes installed outdoors or in wet areas, as determined by the Authority, shall be weatherproof, NEMA 4X, 316 stainless steel, fiberglass reinforced polyester or cast, with mounting flanges where surface mounted, and with union and threaded hubs and gasketed covers. Junction boxes shall be not less than 4 inches square by 1-1/2 inches deep. Box extensions for outlets shall be cast metal and for fixtures may be sheet metal. All boxes subject to moisture shall be provided with 1/8-inch thick neoprene gaskets, threaded hubs and mounting lugs. Galvanized sheet steel outlet or switch boxes

shall not be used as surface mounted pull or junction boxes and surface mounted pull or junction boxes less than 6 inches square shall be cast.

B. Acceptable manufacturers:

1. Cooper Crouse-Hinds; Div. of Cooper Industries, Inc.
2. Hubbell Incorporated.
3. EGS/Appleton Electric.
4. Or equal.

2.08 FIXTURES

- A. Fixtures and lighting equipment as shown on the Drawings shall be complete with all necessary suspension fittings, canopies, hickeyes, casings, socket holders, reflectors, recessed boxes, mounting stanchions, etc. Lamps shall be furnished of the wattage and types as indicated on the Drawings. Fixtures installed in corrosive area shall be explosion proof, NEMA 4X, 316 stainless steel, fiberglass reinforced polyester or cast, with mounting flanges where surface mounted, and with union and threaded hubs and gasketed covers.

2.09 DISCONNECT SWITCH

- A. Disconnect or safety switches shall be provided for all motors 1/8 HP and larger. Switches shall conform to NEMA KS1 and shall be of the ampere capacity, number of poles and voltage rating required and not less than that indicated on the Drawings, and shall be fusible or non-fusible as shown. Switches serving as motor-disconnect means shall be horsepower rated. All switches shall be front operated, heavy duty, quick-make, quick-break, with interlocking covers, and in NEMA Type 12 enclosure indoors. Switches shall be as manufactured by General Electric Company, Cutler-Hammer Co., Square D Co., or equal.
- B. Switches for motors up thru 10 horsepower, 460 volt, 3 phase shall be motor switches, horsepower rated without overload heaters in NEMA Type 1 enclosure indoors and Type 7 in hazardous locations. Switches shall be Square D Class 2510 or equal.

2.10 FUSES

- A. Fuses shall be one time type of the correct voltage and ampere capacity to protect the circuits as shown. Time delay or current limiting, high interrupting capacity fuses shall be used where so indicated on the Drawings.
- B. Fuses for use in high interrupting capacity shall be those employing silver links in a chemically inert filler that will limit the flow of current during high ampere faults.
- C. Spares amounting to one-half of a duplicate set of those installed throughout the facility shall be turned over to the Owner upon completion of the work.
- D. Fuses shall be as manufactured by General Electric Co., Gould Shawmut, Bussman Division, Cooper Industries, or equal.

2.11 CIRCUIT BREAKER

- A. Insulated or molded case circuit breaker: 600 Volt, 3 Pole fully rated, insulated case, with integral fully adjustable solid state trip device. Trip device shall be temperature insensitive and have the following characteristics and functions:
 - 1. Independently adjustable long time pick-up and delay.
 - 2. Independently adjustable short time pick-up and delay with i^2t in and out switch.
 - 3. Adjustable instantaneous.
 - 4. Independently adjustable ground fault pick-up and delay.
 - 5. Trip mode targets for over load, short circuit and ground fault.
 - 6. Long time pick-up light.
- B. Circuit breaker shall be installed in the switchgear or switchboard as shown on the drawing, and shall have a short circuit rating of 42,000 amps RMS symmetrical at 480 volts.
- C. Circuit breaker shall be as manufactured by Square D Co.; General Electric Co.; Cutler- Hammer, or equal.

2.12 PUSHBUTTON STATIONS

- A. Pushbutton stations shall be heavy duty type, momentary or maintained contact type, with pilot lights, locking or lockout devices, and in NEMA 4X enclosure, as indicated on the Drawings or as required by the location. Pilot lights shall be transformer type with 6-volt secondary and primary voltage as required.

Pushbutton stations shall be as manufactured by Square D, Cutler-Hammer Co., General Electric Co., or equal.

2.13 ELECTRIC HEAT TRACING

- A. Provide self-regulating heating cable consisting of flat, flexible parallel copper bus wires embedded in a continuous, self-regulating polymer core. Provide cable with tinned copper braid and overall fluoropolymer outer jacket. Cables are to operate at 120 volts, single phase, as indicated. The heat trace cables shall be LT-10-J by Nelson Heat Tracing Systems or equal by Tyco Thermal Controls or Chromalox.
- B. Provide power connection kits, devices, end seals, mounting hardware, all controls, wiring and conduit necessary for operating heat tracing systems. The power connection kits shall be PLT-BC-J-20 by Nelson Heat Tracing Systems or equal by Tyco Thermal Controls or Chromalox.
- C. Provide a pipe sensing thermostat controller . The controller shall be provided in a NEMA 4X enclosure. The controller shall be TF4X40 by Nelson Heat Tracing Systems or equal by Tyco Thermal Controls or Chromalox.

2.14 PANELBOARDS

- A. Where shown on the Drawings, indicated on the riser diagrams, and listed in the panelboard schedules, furnish and install factory-assembled distribution, power panels of the types and sizes and number of single, two, and three pole breakers listed on the Drawings and Specifications herein. All panels shall utilize copper buswork with bolted breakers.
- B. Receptacle Panelboards. Receptacle panelboards shall be of the dead-front safety type equipped with bolted, quick-make, quick-break thermal magnetic circuit breakers fully rated at a minimum of 10,000 amperes I.C. at 240-volts. Panels bus structure shall be designed for 120/208 volts, three phase, 4 wire and of sufficient capacity to feed the number of branch breakers indicated. Mains shall be equipped with main breakers. Panelboards shall be furnished with separate equipment ground bar.
- C. Panelboard assembly shall be enclosed in a code gauge steel cabinet with flush or surface trim with 6-inch wiring gutters on top, bottom, and sides. Cabinet doors shall be equipped with flush type combination lock and snap catch with 2 milled keys. Doors over 48 inches high shall be provided with a 3 point vault type catch, handle and with lock. A directory frame and index card under transparent plastic shall be provided and each circuit served shall be typed on the index. Panelboards shall be General Electric Co. Type AQ, Square D Co. Type NQOD, Cutler Hammer Type PB or equal.

2.15 DRY TYPE TRANSFORMER

- A. Dry type transformers shall be of voltage, phase, and KVA rating as shown on the Drawings. All transformers shall have four 2-1/2 percent full capacity taps below normal and two 2-1/2 percent taps above normal. All transformers shall have a sound level equal to or better than NEMA standards. All transformers shall be provided with sound dampening "Korfund" rubber pads or mounts and shall be connected by flexible metal connections. Transformers 10 KVA and below shall be of the hardshell totally enclosed encapsulated type suitable for indoor or outdoor operation. All dry type transformers shall have Class H, 220 degree C insulation. Transformers shall be manufactured by Square D Co., Heavy-Duty Electric Co., General Electric Co. or equal.

2.16 CONTROL CABINET

- A. The equipment enclosure shall be two door, free standing, stainless steel, NEMA type 3R. Size of enclosure shall be as indicated on the contract drawings as a minimum or as required to house the equipment. It shall be house flange-mounted disconnect switches and circuit breakers.
- B. Cabinet and door shall be constructed of 316 stainless steel as indicated.
- C. The cabinet door shall be furnished with a gasket, which shall form a watertight seal between the cabinet and door.
- D. Mechanical interlock shall be provided by master door to prevent slave door to be open first.
- E. All equipment installed in enclosure shall be in NEMA 1 enclosures as indicated.

PART 3 EXECUTION

3.01 GENERAL

- A. All equipment, materials, lighting fixtures, etc., shall be installed in accordance with the requirements of all applicable codes, local ordinances and as shown on the Drawings and/or as herein described or directed by the Engineer.

3.02 EQUIPMENT

- A. Cabinets, switches, switchgear and panel board modifications, disconnect switches and similar pieces of equipment, shall be installed at the locations shown on the Drawings. On concrete walls, the equipment shall be attached by means of bolts and expansion shields, and on hollow masonry walls by means of toggle bolts.

- B. Panels shall be installed with the top of the cabinet not over 7 feet 0 inches above the floor level. All equipment shall be installed in a rigid and satisfactory manner, and all incidental materials required for properly mounting equipment shall be furnished and installed to make complete installations satisfactory to the Owner.

3.03 CONDUIT

- A. Conduits shall be run exposed and/or concealed as indicated on the Drawings. Exposed conduits shall be securely fastened in place on not more than 5-foot centers, and hangers, supports or fastenings shall be provided at each end of straight runs, terminating in a box or cabinet. Horizontal and vertical runs may be supported by one-hole malleable straps, clamp backs, or other approved device with suitable bolts, expansion shields, or beam clamps for mounting to structure, or special brackets or machine screws on metal surfaces. Conduit run exterior to buildings, where run underground or in or under concrete slabs in direct contact with the earth shall be PVC coated rigid steel. A touchup compound shall be used on joint sleeves for fusing to conduit coating. A touchup compound shall be used on all exposed threads after the conduit is installed. Underground conduits shall be 2-inch minimum size; 3/4-inch minimum elsewhere.
- B. Flexible Conduit. Flexible conduit shall be used for leads to motors/motor operated valves and where vibration is present or where flexibility of connection is required.
- C. Adjustable trapeze hangers shall be used to suspend groups of exposed parallel runs of conduits. U-bolt clamps or special clips shall be used at the end of each run and at each elbow and at every other supporting channel. The required strength of the supporting equipment, and size and type of anchors used, shall be based on the combined weights of conduit, hanger and cables. The use of perforated iron for supporting conduits will not be permitted. Conduit support systems, strut, threaded rods, screws, conduit straps, and mounting hardware used with the exterior mounted conduits shall be stainless steel. Conduit support systems shall be Kindorf, Unistrut, Globe, or equal.
- D. Conduit shall be installed with runs parallel or perpendicular to walls, structural members, or intersections of vertical planes, with right angle bends consisting of cast metal fitting or symmetrical bends. Bends and offsets shall be made with a hickey or power bender without kinking or destroying the smooth bore of the conduit. Parallel runs shall be run straight and true with offsets uniform and symmetrical. Conduits shall be securely fastened in place to boxes with two locknuts and bushings. Threadless conduit fittings will not be permitted. Minimum size of conduit shall be 3/4-inch. Running threads and threadless couplings will not be permitted. Conduits run exposed shall be provided with 1/4 inch spacers to keep the conduit off wall surfaces.

- E. All conduits run within the building exposed or concealed shall be galvanized rigid steel conduit. Conduits run exposed outdoor shall be rigid steel PVC coated. Conduits run in underground concrete encased shall be PVC schedule 40 except conduits contain analog #16 TS wire, that shall be galvanized rigid steel.

3.04 CABLE

- A. No conductors shall be drawn into any conduit until all work, which may cause cable damage, is completed. Only approved cable lubricants (such as powdered soapstone) shall be used when necessary. As far as practicable, all cable shall be continuous from origin to panel termination without running splices in intermediate pull boxes. Sufficient slack shall be left at the terminations to make proper connections. Branch circuit conductors shall be continuous from outlet to outlet and no splices shall be made except within outlets, junction boxes or pull boxes. Pull boxes shall be utilized where required.
- B. Unless otherwise noted, each conduit raceway shall contain only those conductors constituting a single feeder circuit: where feeders of more than one conductor per phase pass through pull boxes or panels, each conductor of one phase shall be grouped together with conductors of the other two phases to reduce reactance effect. A green equipment grounding conductor shall be run with each feeder and branch circuit.
- C. All cable terminals, taps and splices shall be made with solderless pressure connectors unless otherwise specified. All joints shall be wrapped with self vulcanizing bare rubber tape and friction or plastic electrical insulating tape. Where conductors are to be connected to metallic surfaces, the coated surfaces of the metal shall be polished before installing connector. Lacquer coating of conduits shall be removed where ground clamps are to be installed.
- D. Each control conductor shall be identified at outer terminations by W. H. Brady Co. or equal pressure sensitive vinyl or mylar coated markers to correspond to terminal designations in the distribution equipment.
- E. No wire smaller than No. 12 AWG shall be used. Conductors terminating at wired outlets shall extend at least 8 inches beyond the outlet to facilitate installation of wiring devices or fixtures.
- F. Splices for branch circuits shall be soldered or made with approved pressure or crimp type connectors, such as Ideal Industries nylon insulated wingnut or "Wrap-Cap" insulator or "Scotchlok" brand spring connectors and properly insulated for the system voltage.

3.05 OUTLETS

A. Outlets shall be installed at the approximate locations shown on the Drawings. The Contractor shall study the general building and equipment Drawings in relation to the spaces surrounding each outlet, in order that his work may not conflict with the other work required by these Specifications and to provide the best possible results. Outlet mounting heights shall generally be as follows:

1. Switches: 4 feet-0 inches.
2. Thermostats: 5 feet-0 inches.
3. Receptacles (basement and pump room areas): 3 feet-0 inches.

3.06 JUNCTION BOXES

A. Boxes shall be installed where necessary to facilitate conductor installation. Removable covers shall be accessible at all times. Galvanized steel sheet outlet or switch boxes shall not be used as surface mounted pull or junction boxes unless mounted over 12-feet up and in dry areas (pump rooms are not dry areas) and surface mounted pull or junction boxes less than 6-inches square shall be cast.

3.07 HAZARDOUS LOCATIONS

A. All equipment, fittings and wiring installed in any areas noted as hazardous on the Drawings shall be as approved by the National Electrical Code for Class 1, Division 1, Group D location. Materials shall be of the best quality designed for the type of hazard indicated. At least five full threads shall be engaged on all conduit connections to couplings and fitting hubs. Sealing fitting shall be properly installed at all locations, in accordance with Code regulations.

3.08 MOTORS

A. Motors shall be connected and wired as indicated on the Drawings and in accordance with manufacturer's approved shop drawings and recommendations. Motor controller installation shall be in accordance with the requirements of the National Electrical Code. A disconnect switch shall be provided for each motor or controller, where required by the Code, and/or where indicated on the Drawings. In non-hazardous areas liquid tight flexible metallic conduit shall be used to connect motor terminal boxes to rigid conduit systems. In hazardous areas explosion-proof flexible couplings with outer bronze braid and inner brass core with insulating liner shall be used to connect motor terminal boxes to rigid conduit systems. Motor frames shall be grounded. Every motor starter, pushbutton station and disconnect switch shall be provided with an engraved laminated black on white nameplate securely fastened with pop rivets or stainless steel screws on sheet metal and self-tapping stainless steel screws on cast metal.

3.09 FIXTURES

- A. All fixtures shall be assembled, wired and hung under this section of the Specifications. Number, type and location of fixtures shall conform to the requirements of the Drawings. The Contractor shall review all Drawings to ascertain interferences, special ceiling construction, etc., that may affect the location and manner of hanging fixtures. No splices or taps shall be located within an arm or stem. Fixtures shall be wired with conductors having insulation suitable for the current, voltage and temperature to which the conductors may be subjected and in accordance with NFBU pamphlet No. 70 and the State Electrical codes.

3.10 GROUNDING

- A. The conduit systems, neutral conductors of all wiring systems including the lightning and transformers, shall be grounded.
- B. Grounding shall be provided for conduits and electrical equipment in accordance with the requirements of the National and State Electrical Codes. Where grounding conductors are to be connected to metallic surfaces, the coated surfaces of the metal shall be installed.
- C. Noncurrent carrying metal parts of electrical equipment shall be effectively bonded together and grounded permanently. The size of the system or equipment grounding conductor shall be not less than the sizes given in Tables 250-66 and 250-122 of the National Electrical Code. In no case, shall the equipment grounding conductor be a system neutral or current carrying conductor. A separate green colored ground wire shall be carried with building feeders and branch circuits for equipment grounding. The equipment ground shall be bonded together and to conduits, racks, etc.

3.11 REPAIR OF EXISTING WORK

- A. The work shall be carefully laid out in advance. Where cutting, channeling, chasing or drilling of floors, walls, partitions, ceilings or other surfaces is necessary for the proper installation, support or anchorage of the conduit, raceways or other electrical work, this work shall be carefully done, and any damage to the building, piping or equipment shall be repaired by skilled mechanics of the trades involved at no additional cost to the Owner.

3.12 ELECTRICAL HEAT TRACING

- A. Provide all material, equipment, and labor to install the electric heat tracing system as indicated and as specified.
- B. Install the system in accordance with manufacturer's instruction.

- C. Provide continuous wiring to the extent possible by field conditions in order to minimize splices. Install a marker located at each splice on outside of insulation where the splice is concealed by insulation.
- D. Provide labels “Electric Traced” to the exterior of the insulation. The labels shall be WS-100 by Nelson Heat Tracing Systems or equal by Tyco Thermal Controls or Chromalox.
- E. Megger test cables after installation. Minimum insulation resistance shall be 20 megohms. Submit test report to the Engineer prior to applying power to the system.

3.13 TESTS

- A. After the complete electrical system or systems installation is completed, and at such times as the Authority may direct, the Contractor shall conduct operating tests for approval. All electrical equipment shall be demonstrated to operate in accordance with the requirements of this and other Sections of the Specifications. The variable frequency drive testing shall include the following:
 - 1. The Contractor shall perform field tests in accordance with the Specifications. The variable frequency drives shall be field tested for operation and conformance.
 - 2. The manufacturer’s representative, prior to energizing equipment, shall perform variable frequency drive testing. Equipment shall not be energized without the permission of the Owner. The testing shall be in accordance with the recommendations of the manufacturer's representative and shall consist at a minimum of the following:
 - a. Device settings and drive adjustments shall be verified.
 - b. Mechanical and electrical interlocks shall be inspected and controls shall be checked for proper operation.
 - c. Each drive shall be tested through the specified speed ranges and loads for a minimum of two hours.
 - d. Each drive shall be tested by using the actual control signal for remote and local operation.
 - e. Each drive alarm function shall be tested.
- B. Wire and Cable Testing: Perform the following field quality-control testing:
 - 1. After installing conductors and cables and before electrical circuitry has been energized, test for compliance with specified requirements.

2. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.3.1. Certify compliance with test parameters.
- C. Heat Trace System Testing:
 1. Megger test all heat trace cable prior to applying power.
 2. Test system for proper operation after the insulation has been installed and lines have been filled with liquid.
- D. Test Reports: Submit a written report to the Engineer for each test specified above to record the following:
 1. Test procedures used.
 2. Test results that comply with requirements.
 3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

3.14 MANUFACTURER'S FIELD SERVICES

- A. A qualified manufacturer's service representative shall assist in the installation of equipment; including but not limited to the circuit breakers, to check the equipment installation before it is placed into operation, assist in the performance of field tests, observe and assist initial operations and train the plant operations and maintenance staff in the care, operation and maintenance of the equipment.
- B. The Contractor shall provide equipment start-up services and training in accordance with the Detailed Specifications.
- C. The Contractor shall provide a field report from the manufacturer's representative for each visit to the site. The report shall include complete information on time, schedule, tasks performed, persons contacted, problems corrected, tests results, training, instruction and all other pertinent information.
- D. The service representative shall provide 24-hour advanced notification to the Owner for each day they plan to be at the site.
- E. Existing plant functions must be maintained and any projected plant operations shutdown shall be coordinated with the plant operator.
- F. The VFD service technician shall be responsible for coordination with the system integrator as required.

** END OF SECTION **