

SECTION 16000

BASIC ELECTRIC 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 furnish 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 completely therewith. All electrical work shall be complete and left in operating condition in accordance with the intent of the Drawings and Specifications for the electrical work.
- B.** Reference Section 17000, Control and Information System Scope and General Requirements for the scope of work details as they relate to the Division 17 Contractor.
- C.** The electrical scope of work for this project primarily includes, but is not limited to, the following:
1. Furnish, assemble, and install PLC electrical enclosures indicated on the Drawings.
 2. Furnish and install all raceway systems including conduit and fittings required for signals and components being added to the control system.
 3. Furnish and install all low voltage wire and cable as required for signals and components being added to the control system.
 4. Modifications to existing electrical equipment as specified herein and indicated on the Drawings.
 5. Other electrical work as specified herein and indicated on the Drawings.
- D.** All material and equipment must be the product of an established, reputable and approved 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 CMCMUA.
- E.** When a specified or indicated item has been superseded or is no longer available, the manufacturer's latest equivalent type or model of material or equipment as approved by the CMCMUA shall be furnished and installed at no additional cost to the CMCMUA.

- F. 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 including software programming, subject to the approval of the CMCMUA. The Contractor's bid shall include all costs for all work of the Contractor for all trades made necessary by such changes, additions or modifications or resulting from any approved substitution.
- G. 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 other specified or indicated on the Drawings.
- H. All electrical components and systems, including electrical equipment foundations, shall be designed to resist operational forces as well as lateral sway and axial motion seismic and thermal forces. Seismic support design shall be in accordance with Section 01350 – Seismic Anchorage and Bracing.

1.02 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 the 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 ensure that the proposed equipment will fit properly in spaces indicated.
- B. Where outlets are shown near identified equipment furnished by this or other Contractors, it is the intent of the Specifications or 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.

1.03 LOCAL CONDITIONS

- A. The Contractor shall examine the site and become familiar with conditions affecting the work. The Contractor 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 with all authorities having jurisdiction. All costs, both temporary and permanent connections to 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.
- B. In addition, the Contractor shall relocate all duct banks, lighting fixtures, receptacles, switches, boxes, and other electrical equipment as necessary to facilitate the Work included in this project. Costs for such work shall be included in the Bid.

1.04 SUBMITTALS

- A.** In accordance with the procedures and requirements set forth in the General Conditions, Section 01300, Submittals and the requirements of the individual specification sections, the Contractor shall obtain from the equipment manufacturer and submit the following:
 - 1. Shop Drawings
 - 2. Operation and Maintenance Manuals
 - 3. Spare Parts Lists
 - 4. Proposed Testing Methods and Reports of Certified Shop Tests.
 - 5. Reports of Certified Field Tests.
- B.** Submittals shall sufficiently complete in detail to enable the CMCMUA to determine compliance with contract requirements.
- C.** Submittals shall 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 the Contractor has provided no information.
- D.** Some individual Division 16 specification sections may require a Compliance, Deviations, and Exceptions (CD&E) letter to be submitted. If the CD&E letter is required and shop drawings are submitted without the letter, the submittal shall be rejected. The letter shall include all comments, deviations and exceptions taken to the Drawings and Specifications by the Contractor AND Equipment Manufacturer/Supplier. This letter shall include a copy of this specification section. In the left margin beside each and every paragraph/item, a letter "C", "D", or "E" shall be typed or written in. The letter "C" shall be for full compliance with the requirement. The letter "D" shall be for a deviation from the requirement. The letter "E" shall be for taking exception to a requirement. Any requirements with the letter "D" or "E" beside them shall be provided with a full typewritten explanation of the deviation/exception. A handwritten explanation of the deviations/exceptions shall not be acceptable. The CD&E letter shall also address deviations and exceptions taken to each Drawing related to this Specification Section.

1.05 APPLICABLE CODES AND REQUIREMENTS

- A.** Conformance:
 - 1. All work, equipment and materials furnished shall conform with the existing rules, requirements, and specifications of the following:
 - a. Insurance Rating Organization having jurisdiction

- b. The serving electrical utility company
 - c. The currently adopted edition of the National Electrical Code (NEC)
 - d. The National Electric Manufacturers Association (NEMA)
 - e. The Institute of Electrical and Electronics Engineers (IEEE)
 - f. The Insulated Cable Engineers Association (ICEA)
 - g. The American Society of Testing Materials (ASTM)
 - h. The American National Standards Institute (ANSI)
 - i. The requirements of the Occupational Safety Hazards Act (OSHA)
 - j. The National Electrical Contractors Association (NECA) Standard of Installation
 - k. National Fire Protection Association (NFPA)
 - l. International Electrical Testing Association (NETA)
 - m. 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 are of the class inspected by said laboratories.

B. Nonconformance:

1. Any paragraph of requirements of 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 shall not be allowed as an extra but shall be included in the Bid. Ignorance of any rule, requirement or Specification shall not be allowed as an excuse for nonconformity. Acceptance by the CMCMUA 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 a certificate(s) of inspection and approval from the National Board of Fire Underwriters or similar inspection organizations having jurisdiction and shall deliver the same to the CMCMUA.

1.06 PERMITS AND INSPECTIONS

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

1.07 TEMPORARY LIGHTING AND POWER

- A. The Contractor shall responsible for all temporary lighting and power.

1.08 TESTS

- A. Upon completion of the installation, the Contractor shall perform tests for operation, overloads, and short circuits. Tests shall be made with and to the satisfaction of the CMCMUA.
- 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 CMCMUA. The Contractor shall show by demonstration in service that all circuits and devices are in good operating condition. The test shall be such that each item of control equipment will function not less than five (5) times.
- C. Refer to each individual specification section for detailed test requirements.
- D. The Contractor shall complete the installation and field testing of the electrical installation at least one (1) week 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.

1.09 SCHEDULES AND FACILITY OPERATIONS

- A. Since the equipment testing required herein shall require that certain pieces of equipment be taken out of service, all testing procedures and schedules must be submitted to the CMCMUA for review and approval one (1) month prior to work beginning. When testing has been scheduled, the CMCMUA must be notified 48-hours prior to any work to allow time for load switching and/or alternation of equipment. In addition, all testing that requires a temporary shutdown of facility equipment must be coordinated with the CMCMUA so as not to affect proper facility operations.
- B. At the end of the workday, all equipment shall be back in place and ready for immediate use should a facility emergency arise. In addition, should an emergency condition occur during testing, at the request of the CMCMUA, the equipment shall be placed back in service immediately and turned over to the CMCMUA's personnel.

- C. In the event of an accidental shutdown of CMCMUA equipment, the Contractor shall notify CMCMUA personnel immediately to allow for an orderly restart of affected equipment.
- D. Maintaining the operation of these facilities during the duration of the construction period is essential and required. The Contractor shall furnish and install temporary equipment as required to maintain facility operation. Reference Section 01520 of the Specifications for construction sequencing and specific operational constraint information.

1.10 MATERIALS HANDLING

- A. Materials arriving on the job site shall be stored in such a manner as to keep the 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 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 CMCMUA at no additional cost to the CMCMUA. If space heaters are provided in a piece of electrical equipment, they shall be temporarily connected to a power source during storage. The Contractor shall store equipment and materials in accordance with Section 01550, Site Access, and Storage.

1.12 WARRANTIES

- A. Unless otherwise specified in an individual specification section, all equipment and electrical construction materials furnished and installed under Division 16 shall be provided with a manufacturer's warranty in accordance with the equipment supplied.

PARTS 2 – PRODUCTS

2.01 PRODUCT REQUIREMENTS

- A. Unless otherwise indicated, the materials to be provided under this Specification shall be 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, IEC and NEMA, unless specified otherwise.
- 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 CMCMUA that the materials, appliances, equipment or devices that are provided 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. shall be accepted as conforming to this requirement.

2.02 SUBSTITUTIONS

- A. Unless specifically noted otherwise, any reference in this Specification 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 be not construed as limiting competition. The Contractor, in such cases may, as an option use any article, device, product, material, fixture, or item of equipment which in the judgment of the CMCMUA, expressed in writing, is equivalent to that specified.

2.03 CONCRETE

- A. The Contractor shall furnish all concrete required for the installation of all electrical work, Concrete shall be Class A unless otherwise specified. Concrete and reinforcing steel shall meet the appropriate requirements of Division 3 of the Specifications.
- B. The Contractor shall provide concrete equipment pads for all free-standing electrical apparatus and equipment located on new or existing floors or slabs. The Contractor shall provide all necessary anchor bolts, channel iron sills and other materials as required. The exact location and dimensions shall be coordinated for each piece of equipment well in advance of the schedules placing of these pads. Equipment pads shall be 4 inches high unless otherwise indicated on the Drawings and shall conform to standard detail for equipment pads shown on the Contract Drawings. Equipment pads shall not have more than 3-inches of excess concrete beyond the edges of the equipment.
- C. The Contractor shall provide concrete foundations for all free-standing electrical apparatus and equipment located outdoors or where floors or slabs do not exist and/or are not provided by others under this Contract. The Contractor shall provide all necessary anchor bolts, channel iron sills, and other materials as required. The location and dimensions shall be coordinated for each piece of equipment well in advance of the schedule 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 referenced 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.

2.04 RUBBER INSULATING MATTING

- A. Rubber insulating matting shall be furnished and installed on the floor and in front of each piece of electrical equipment that is located indoors and installed under this Contract. Rubber insulating matting shall not be installed outdoors. The mat shall be long enough to cover the full length of the equipment. The mat shall be ¼ inch thick with beveled edges, canvas back, solid type with corrugations running the entire length of the mat. The matting shall meet OSHA requirements and the requirements of ASTM D-178 for Type 2, Class 2 insulating matting. Matting shall be 36-inches wide, minimum. However, matting

width shall be no less than the NEC working clearance for the equipment with which it is associated.

B. Matting shall be provided for the following new equipment:

- PLC Enclosures
- Motor Control Centers
- Variable Frequency Drives

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 this Contract. Any damage to the building, structure, or any equipment shall be repaired by qualified mechanics of the trades involved at the Contractor's expense. If in the CMCMUA's judgment, the repair of damaged equipment would not be satisfactory, then the Contractor shall replace damaged equipment at the Contractor's own expense.

C. Existing Equipment

1. Provide a suitable cover or plug for openings created in existing equipment as the result of work under this Contract. For example, provide round plugs in equipment enclosures where the removal of a conduit creates a hole in the enclosure. Covers and plugs shall maintain the NEMA rating of the equipment enclosure. Covers and plugs shall be watertight when installed in equipment located outdoors.

3.02 EXCAVATION AND BACKFILLING

- A. The Contractor shall perform all excavation and backfilling 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

- B. Wherever dissimilar metals, except conduit and conduit fittings, come into contact, the Contractor shall isolate these metals as required with neoprene washer, nine (9) mil polyethylene tape, or gaskets.

(END OF SECTION)

SECTION 16035
DEMOLITION - ELECTRICAL

PART 1 – GENERAL

1.01 SECTION INCLUDES

- A.** Requirements for providing demolition work. This section also includes equipment relocation. The demolition and relocation work shall be performed in accordance with the requirements specified under this Section and the Contract Drawings.
- B.** The Contractor shall also relocate electrical equipment. The extent of the demolition and relocation work is shown on the Contract Drawings.

1.02 REFERENCES

- A.** Demolition work shall comply with the latest applicable provisions and recommendations of the following:
 - 1.** NFPA 70, National Electrical Code.

1.03 QUALITY ASSURANCE

- A.** All demolition and removal work shall be in accordance with the National Electrical Code, NFPA 70.
- B.** In the performance of the demolition work, the Contractor shall provide protection of adjacent plant areas, existing equipment, and on-going construction. No electrical equipment shall be disposed off-site without the written approval of the CMCMUA.
- C.** The Contractor shall execute the work in a careful and safe manner with the least possible disturbance to the operation of the facility. All work shall be performed with due regard to the maintenance of utility operations during construction.
- D.** Demolition and removal work shall be executed with care and performed by competent experienced workers for the various types of demolition and removal work. All patching, replacing, and refinishing of work shall be done by skilled workers.
- E.** The Contractor shall make such investigations, explorations and probes as are necessary to ascertain any required protective measures before proceeding with demolition and removal. The Contractor shall be responsible for any damage which may be caused by demolition and removal work to any part or parts of existing structures or equipment designated for reuse or to remain.

- F. The Contractor shall coordinate with the CMCMUA to disconnect or remove sources of power to equipment being removed or relocated.

1.04 SITE CONDITIONS

- A. The CMCMUA assumes no responsibility for the actual condition of structures to be demolished and removed. Conditions existing at the time of inspection for bidding purposes shall be noted by the Contractor and shall be used in preparing the bid.
- B. The Contractor shall perform the work with due regard that in some areas only certain systems and equipment shall be demolished while other systems and equipment shall remain operational. The Contractor shall field determine and make such investigations as required to determine the source and function of each circuit, to allow for the disconnection and removal of each circuit not required as a result of the demolition and to retain all active circuits for areas unaffected by the demolition work.

1.05 SCHEDULING

- A. The Contractor shall proceed with the demolition and removal of equipment in a sequence designed to maintain the existing facility in operation. The Contractor shall notify the CMCMUA seven (7) days before proceeding and meet with plant personnel to review removals and demolition work. Work shall begin only after approval of the CMCMUA.
- B. Close coordination with CMCMUA Operations Personnel shall be maintained whenever equipment is taken offline, removed from an existing PLC, or moved from an existing PLC to a new PLC. It is the intent of this contract that no equipment shall be taken offline without approval from the CMCMUA Operations Personnel in order to maintain proper wastewater treatment throughout this project. High flow events such as large storms, flood events, and major summer holidays may disrupt the ability to remove equipment from service. Proper project planning 48 hours ahead of time in order to remove equipment from service shall be adhered to by the Contractor.
- C. Any equipment and appurtenances removed without proper authorization, which is necessary for the operation of the existing facility, shall be replaced to the satisfaction of the CMCMUA at no additional cost.

PART 2 – PRODUCTS (Not Applicable in this Section)

PART 3 -- EXECUTION

3.01 PREPARATION

- A. The Contractor shall provide protection and restoration of structures. Catch platforms, lights, barriers, weather protection, warning signs, and other items shall be provided as required for proper protection of the public, occupants of the building, workers engaged in demolition operations, and adjacent construction.

- B.** The Contractor shall provide temporary protection of the existing structure designated to remain where demolition, removal and new work is being done, connections made, materials handled or equipment moved.
- C.** The Contractor shall provide dust proof partitions to prevent dust from rising by wetting demolished masonry, concrete, plaster and similar debris. Unaltered portions of the existing equipment affected by the demolition shall be protected. Such enclosures shall be required in areas of major demolition work and for protection of existing equipment and personnel. Insulating barriers shall also be provided where necessary for protection.
 - 1.** Dustproof partitions shall be constructed of wood studs with plywood on both sides. Partitions shall extend from floor to ceiling with a closure plate at the floor and ceiling and a dust-tight door in each enclosure complete with hardware, attached, and keyed.
 - 2.** Insulation barriers shall be provided to cover exposed, energized terminals, wires, and busses.
 - 3.** Adequate ventilation shall be provided for a safe working environment.
- D.** The Contractor shall not close or obstruct roadways, walkways, passageways, or stairways and shall not store or place materials in passageways, stairs or other means of egress.
- E.** The Contractor shall repair any damage to the existing structure or contents by reason of the insufficiency of protection provided.

3.02 REMOVALS

- A.** The Contractor shall demolish or relocate electrical equipment as shown on the Contract Drawings.
- B.** All exposed conduits shall be removed and disposed of. Conduits underground or concealed shall be abandoned. Abandoned conduits shall be cut flush with the slab or wall at the point of entrance and plugged.
- C.** Recessed equipment to be demolished shall be abandoned unless otherwise noted on the Contract Drawings. Demolished recessed panelboards, boxes, enclosure fronts, and internals shall be completely removed. The enclosure fronts shall be covered with new blank cover plates.
- D.** Wherever cable and conduit are to be removed for disposition, the circuit shall be de-energized by the Contractor and adjacent circuits that are to remain in service shall be blanked off and then isolated.

- E. All supports, pedestals and anchors for conduits, lighting fixtures and other equipment shall be removed with the equipment unless otherwise noted on the Contract Drawings. Concrete bases, anchor bolts and other supports shall be removed to approximately one (1) inch below the surrounding finished area and the recesses shall be patched to match the adjacent areas.
- F. Where equipment is indicated to be removed, relocated and reused, the equipment shall be removed or relocated with care to prevent unnecessary damage, under the supervision of the trade responsible for reinstallation and protected and stored until required. Material or items damaged during removal shall be replaced with similar new material or items at no additional cost to the CMCMUA.

3.03 CLEANING AND MAINTENANCE

- A. The Contractor shall maintain the existing electrical power system to operate without interruption. Any interruption of electrical power to the existing facility and equipment shall be with the written approval and permission of the CMCMUA.
- B. The Contractor shall maintain all protection facilities installed in preparation of the demolition work.
- C. The Contractor shall provide on-site dump containers for collection of waste materials, debris and rubbish.
- D. All existing surfaces shall be cleaned of dirt, grease, loose paint before refinishing.
- E. The Contractor shall clean the site and properties of dust, dirt, and debris caused by the demolition and removal work. Waste materials, debris and rubbish shall be disposed of and the areas shall be returned to conditions prior to the start of the work.

(END OF SECTION)

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, And Section 16195 – Electrical Identification.
- D. All Contractor personnel installing PVC coated rigid conduit shall be trained as specified herein.

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 shall be returned to the Contractor without review for resubmittal.
- C. Shop drawings shall include but not be limited to:
 - 1. Product datasheets.
 - 2. Conduit identification methods and materials.
 - 3. Evidence of training (e.g. Certificates of Completion) for all Contractor personnel that will install PVC coated rigid conduit. Training shall be as specified herein.

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, heavily walled aluminum. Minimum size conduit shall be 3/4 inch unless otherwise indicated on the Drawings. Unless specified otherwise herein or indicated on the Drawings, all encased conduits shall be PVC Schedule 40, minimum size 1 inch. The Contractor, as an 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 shall be permitted in these larger conduits.

All components (fittings, couplers, connectors, etc.) of the conduit system shall be of the same or compatible material of construction. 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 equivalent.
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. Rigid Aluminum Conduit

1. Aluminum conduits shall be rigid type, heavy-walled as manufactured by Allied Tube and Conduit Corporation, Wheatland Tube Company, Jones & Laughlin Steel Company, or approved equivalent.
2. Rigid aluminum conduit shall be manufactured of 6063 alloys in temper designation T1. Fittings shall be of the same alloy.
3. Rigid aluminum conduit shall be listed by Underwriters' Laboratories to U.L. Standard 6A shall be manufactured to ANSI Standard C80.5.
4. Each length of conduit shall be shipped with a coupling on one end and a color-coded thread protector at the other end.

D. Flexible Metal Conduit

1. Flexible metal conduit (FMC) shall be galvanized steel, single strip. FMC shall be UL listed. FMC shall be used to connect all indoor vibrating equipment, installed in dry locations, above reflected ceilings to lighting fixtures, and other applications as accepted by the CMCMUA. FMC shall be Galflex Type RWS as manufactured by Southwire, Type BR as manufactured by Electri-Flex, or equivalent.

E. Liquid-Tight Flexible Metal Conduit

1. Liquid-tight flexible metal 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 Titan Type UL as manufactured by Southwire, Liqueflex Type "LA" as manufactured by Electri-Flex, Anaconda Type UA as manufactured by Anamet Electrical, Inc., or equivalent.

2. PVC coated or stainless-steel 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 CMCMUA.

F. Liquid-Tight Flexible Non-Metallic Conduit

1. Liquid-tight flexible non-metallic conduit (LFNC) shall be constructed of PVC. LFNC shall be UL listed. LFNC shall have an extruded moisture and oil-proof PVC jacket. LFNC shall be Ultratite Type NM as manufactured by Southwire, Type NM as manufactured by Electri-Flex, Anaconda Type NMUA by Anamet Electrical, Inc., or equivalent.
2. Watertight connectors shall be used with liquid-tight flexible non-metallic conduit on both ends. LFNC shall be used to connect all vibrating equipment installed in sodium hypochlorite storage and transfer areas as specified herein, and other applications as directed by the CMCMUA or as indicated on the drawings.

G. 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 equivalent.

H. PVC Coated Metallic Conduit

1. PVC coated rigid aluminum conduit shall be furnished and installed as specified herein and indicated on the Drawings. The product shall be rigid aluminum conduit covered with a bonded 40 mil (minimum) thickness PVC jacket and coated inside with urethane. The conduit shall comply with NEMA RN-1 and shall be "Plasti-Bond Red" as manufactured by Robroy Industries, "OCAL-Blue" as manufactured by Thomas & Betts, Perma-Cote Supreme by Perma-Cote Industries, Kor Kap equivalent, or equivalent.

I. Innerduct

1. Innerduct shall be High Density Polyethylene (HDPE) type SDR11 and conform to ASTM D3035.
2. Innerduct conduit shall be as manufactured by Carlon, Endot or equivalent.

J. Conduit Fittings

1. Fittings for all conduit types shall conform to UL 467 and UL 514 as applicable.

2. Fittings for electrical metallic tubing shall be rain-tight and concrete-tight, and shall be plated steel hexagonal threaded compression type.
3. Set screw or indenter 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 across structural expansion joints, approved weatherproof telescopic type expansion fittings shall be used. Fittings shall be OZ/GEDNEY Type AX, Crouse-Hinds Type XJG, or equivalent, watertight, and permit movement up to 4 inches. Each fitting shall be equipped with approved bonding jumpers around or through each fitting.

Where embedded conduits pass-through expansion joints, approved watertight, concrete-tight deflection/expansion fittings shall be used. Fittings shall compensate for the movement of 3/4-inch from the normal in all directions. Fittings shall be OZ/GEDNEY Type DX, Crouse-Hinds Type XD, or equivalent.

6. Conduit fittings ("condulets") shall be used on exposed conduit work for 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 equivalent. 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 the 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.
8. PVC coated fittings shall be used with PVC coated conduit. All conduit nipples, elbows, couplings, boxes, fittings, unions, expansion joints, connectors, bushing, and other components of the raceway system shall be factory coated to maintain the corrosion-resistant integrity of the conduit system. The coated conduit and its respective components shall all be provided by the same manufacturer. Coated conduit shall be used in all areas specified herein or indicated on the Drawings.
9. Conduit seals shall be Type EYS as manufactured by Crouse-Hinds, Appleton equivalent, OZ/Gedney equivalent, or equivalent.

PART 3 -- EXECUTION

3.01 CONDUIT AND FITTINGS

- A.** Unless otherwise specified herein or indicated on the Drawings, the minimum size conduit shall be 3/4 inch for exposed work and 1 inch for conduit encased in concrete or mortar.
- B.** Conduit home runs for 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 CMCMUA.
- C.** Conduit shall be installed concealed unless otherwise indicated or specified. The conduit may be run exposed on walls only where concealing is not practical, or at the direction of the CMCMUA.
- 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.** A non-metallic raceway containing instrumentation cable (if specifically allowed herein) where installed exposed 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.
- F.** Where practical, exposed raceways containing instrumentation cable shall cross raceway containing conductors of other systems at right angles.
- G.** For floor-mounted equipment, conduit may be installed 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 free from all obstructions.
- H.** Empty conduit systems shall be furnished and installed as indicated on the Drawings and shall have pull ropes installed. The polyethylene pull ropes shall be 1/4" diameter, minimum. Not less than 12 inches of slack shall be left at each end of the pull rope.
- I.** 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 galvanizing and conducting compound shall be applied to the threads. Galvanizing compound shall be CRC Zinc-It or equivalent. 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. Where standard coupling cannot be used, an Erickson three-piece couplings shall be used. Where conduits are installed in concrete, concrete-tight three-piece couplings shall be used.
- J.** Conduit threaded in the field shall be of standard sizes and lengths.

- K. 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 is 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

All conduit for fiber optic cable shall have a minimum bending radius of 16 inches. The final bending radius shall be determined by the fiber optic cable manufacturer.

- L. Unless otherwise specified herein, indicated on the Drawings, or required by the NEC, conduit shall be supported every 8 feet (minimum) 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 one (1) foot of all changes in direction. Supports shall be approved pipe straps, wall brackets, hangers or ceiling trapeze. Supports shall be in accordance with Section 16190 – Supporting Devices.
- M. 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. Powder actuated fasteners may only be used to make connections where the use of this equipment complies with safety regulations and for structures in Seismic Design Categories A or B unless the fasteners are approved for seismic use. Wooden plugs inserted in masonry and the use of nails as fastening media are prohibited. Threaded C-clamps may be used on rigid steel conduit only. Conduits or pipe straps shall not be welded to steel.
- N. 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 the 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 finished slab. Where embedded conduits cross expansion joints, suitable expansion/deflection 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. Embedded conduits shall be placed in accordance with the latest edition of ACI-318.
- O. 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 expansion/deflection 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. Embedded conduits shall be placed in accordance with the latest edition of ACI-318.

- P. Install polyvinyl chloride (PVC) coated steel conduits when entering or exiting concrete except under electrical equipment where the conduit is not subject to physical abuse. Also, install a PVC coated steel conduit when transitioning between grade and a structure or an equipment stand. 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 PVC coated rigid steel conduit.
- Q. Aluminum conduits shall not be in contact with concrete surfaces. Where aluminum conduits are routed along concrete surfaces, they shall be installed with one hole cast straps with clamp-backs to space the conduit $\frac{1}{4}$ " away from the concrete surface. Where aluminum conduit passes through concrete, CMU or brick walls, the penetration shall be made such that the aluminum conduit does not come in contact with concrete, CMU, brick or mortar. All penetrations shall meet or exceed the UL design standards. Aluminum conduit shall transition to PVC coated steel conduit were entering a concrete encasement, floor, or duct bank.
- R. 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.
- S. 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 PVC coated rigid steel conduit at the point where it leaves the ground, with the transition to metal conduit occurring inside the concrete encasement.
- T. No more than three (3) 90-degree bends shall be allowed in any one conduit run. Where more bends are necessary, a conduit or pull box shall be installed. All bends in 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 shall be 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.
- U. 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. Screwdriver operated threaded flush plugs shall be installed in conduits from which no equipment connections are made.
- V. 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 CMCMUA.

- W.** 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.
- X.** Where "all-thread" nipples are used between fittings and electrical equipment, they shall be so installed that no threads are exposed.
- Y.** 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 three (3) feet, maximum.
- Z.** 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 the flexible conduit. This conductor shall be terminated to the nearest pull box, motor terminal box, or any other apparatus ground terminal. Flexible metal conduit and liquid-tight flexible metal conduit shall be grounded and bonded per NEC Articles 348 and 350, respectively.
- AA.** 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 equivalent. 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, or equivalent. For conduit penetrations through openings in concrete walls, the fittings shall be Type WSK Thruwall seals as manufactured by OZ Gedney, or equivalent. 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.

- AB.** 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, wire ways, 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.

- AC.** The use of two (2) locknuts, one on each side of the enclosure, 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.
- AD.** Conduit installation shall be arranged to minimize cleaning. No horizontal runs of conduit shall be permitted in brick or masonry walls.
- AE.** Install non-metallic conduits in accordance with manufacturer's instructions where specified herein or indicated on the Drawings.
- AF.** Join the non-metallic conduit using cement as recommended by the manufacturer. Clean and wipe non-metallic conduit dry before joining. Apply a full even coat of cement to the entire area inserted in fitting. Allow the joint to cure for twenty (20) minutes (minimum).
- AG.** All PVC coated conduit shall be installed in accordance with manufacturer's instructions. The Contractor shall use tools that are specifically suited for coated conduit systems. The use of pipe wrenches and other such tools on PVC coated RGS conduit is prohibited. The CMCMUA reserve the right to reject any installation of a coated conduit that does not meet the requirements of the Section or the manufacturer's instructions. The CMCMUA also reserve the right to reject any installation that exhibits damage due to the improper use of tools. All rejected installations shall be replaced by the Contractor at no additional cost to the CMCMUA. The use of PVC coated conduit repair compounds to repair damages or improper installation is prohibited.
- AH.** All Contractor personnel that installs PVC coated RGS conduit shall be trained by the PVC coated RGS conduit manufacturer. Training shall include proper conduit system assembly techniques, use of tools appropriate for coated conduit systems, and field bending/cutting/threading of coated conduit. The Contractor shall furnish evidence of such training as specified herein. Training shall have been completed within the past 24 months prior to the Notice to Proceed on this Contract for all coated conduit installation personnel. Contractor personnel not trained within this timeframe shall not be allowed to install coated conduit, or shall be trained/re-trained as required prior to commencement of conduit installation.
- AI.** Conduits shall not penetrate the floors or walls inside liquid containment areas unless specifically accepted by the CMCMUA.
- AJ.** All conduits that are buried or encased in concrete that transition from the ground to any stationary structure or equipment shall be equipped with a longitudinal expansion coupling capable of at least four inches of expansion. Conduits with encasement that is rigidly tied to the stationary structure in accordance with the Standard Details shall not be required to have expansion couplings.
- AK.** Raceways shall not be installed concealed in water-bearing walls and floors.
- AL.** Where flexible conduit is required in a Class 1, Division 1 Hazardous area, a type ECGJH braided flexible coupling shall be used, as manufactured by Crouse-Hinds, or equivalent. Braiding and ends shall be of stainless-steel construction. Couplings using un-coated copper braid shall not be acceptable.
- AM.** The Contractor shall furnish and install conduit entering or leaving NEC Article 500 hazardous areas with conduit seals. The Contractor shall also install conduit entering or leaving areas of buildings in which sodium hypochlorite is stored or distributed with conduit seals. The Contractor shall furnish and install conduit seals in other hazardous locations as required by the NEC.

3.02 CONDUIT USES AND APPLICATIONS

- A. No PVC conduit shall be installed exposed unless specifically accepted in writing by the CMCMUA. Where PVC conduit is allowed to be installed exposed, the conduit shall be Schedule 80.
- B. 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. PVC coated rigid aluminum conduit shall be installed in all elevated slabs when the conduits are shown to be encased.
- C. PVC Schedule 40 conduit shall be installed in the reinforced concrete encasement. Conduit shall be "direct buried" only if specifically indicated on the Drawings.
- D. All instrumentation wire and cable for analog signals shall be installed in rigid aluminum conduit or PVC coated rigid aluminum conduit to suit the application. This applies to all conduit installations including exposed, concealed in a concrete encasement, and all other applications.
- E. Rigid aluminum conduit shall be furnished and installed, where exposed, in the following areas:
 - 1. All outdoor locations.
 - 2. All indoor Areas
- F. Liquid-tight flexible non-metallic conduit (LFNC) shall be furnished and installed, where required, in chemical storage and transfer areas.
- G. Other conduit uses not specifically listed above shall be brought to the attention of the CMCMUA for a decision.

3.03 CONDUIT IDENTIFICATION

- A. Exposed conduits shall be identified at the source, load, and all intermediate components of the raceway system. Examples of intermediate components include but are not limited to junction boxes, pull boxes, conduits, and disconnect switches. Identification shall be by means of an adhesive label with the following requirements:
 - 1. Labels shall consist of an orange background with black text. Text for the label shall be the conduit number as indicated in the conduit and wire schedules.
 - 2. In addition, at the source end of the conduit, the second line of text shall be included to indicate the load equipment name. This second line shall consist of the word "TO:" and the text in the 'TO' column of the conduit and wire schedule (e.g. TO: Blower AB-1). At the load end of the conduit, the second line of text shall be included to indicate the source equipment name. This second line shall consist of the word "FROM:" and the text in the 'FROM' column of the conduit and wire schedule (e.g. FROM: MCC-BB). This requirement applies only to the source and load ends of the conduit, and not anywhere in between.
 - 3. For conduits ¾" through 1½" in size, the text shall be a minimum 18 point font. For conduits 2" and larger, the text shall be a minimum 24 point font.

4. Label height shall be $\frac{3}{4}$ " minimum, and length shall be as required to fit the required text. The label shall be installed such that the text is parallel with the axis of the conduit. The label shall be oriented such that the text can be read without the use of any special tools or removal of equipment.
 5. Labels shall be installed after each conduit is installed and, if applicable, after painting. Labels shall be printed in the field via the use of a portable label printing system. Handwritten labels shall not be acceptable.
 6. Labels shall be made of permanent vinyl with industrial grade adhesive backing, and suitable for the environment, manufactured by Brady, Seton, Panduit, or equivalent. Labels made of any other material shall not be acceptable.
- B. Conduits that are not exposed but installed beneath free standing equipment enclosures shall be identified by means of a plastic tag with the following requirements:
1. The tag shall be made of white Tyvek material, and have an orange label with black text, as described above, adhered to it. Text for the label shall be the conduit number as indicated in the conduit and wire schedules.
 2. The tag shall be affixed to the conduit by means of a nylon cable tie. The tag shall be of suitable dimensions to achieve a minimum text size of 18 points.
 3. Tags shall be White Tyvek as manufactured by Brady, Seton equivalent, Panduit equivalent, or equivalent.
- C. Conduits for lighting and receptacle circuits shall not require identification.
- D. Alternatives to this proposed conduit identification method shall be submitted to the CMCMUA as part of the shop drawing submittal.
- E. Any problems or conflicts with meeting the requirements above shall immediately be brought to the attention of the CMCMUA for a decision.

3.04 TESTING

- A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests shall be required:
1. 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 installed below grade or concrete encased shall be tested to ensure continuity and the absence of obstructions by pulling through each conduit a swab followed by a mandrel 85% of the conduit inside diameter. After testing, all conduits shall be capped after installation of a suitable pulling tape.

(END OF SECTION)

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 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.
- C. 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. Cable and wiring shall be tested in accordance with the applicable ICEA Standards. Wire and cable shall be physically and electrically tested in accordance with the manufacturer's standards.
 - 3. Field Tests for 6 AWG wires and larger
 - a. Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 1, and NETA acceptance testing specifications referenced in Section 16000, Basic Electrical Requirements.
 - b. After installation, all wires and cables shall be tested for continuity. Testing for continuity shall be "test light" or "buzzer" style.
 - c. After installation, all wires and cables shall be tested for insulation levels. 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 one (1) minute for all 600V wires and cables installed in lighting, control, power, indication, alarm and motor feeder circuits. Resistance shall be no less than 100 Megaohms.
 - (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 equivalent. 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 CMCMUA, without additional cost to the CMCMUA.
 - E. All tests shall be made by and at the expense of the Contractor who shall supply all testing equipment. Test reports shall be submitted to the CMCMUA.

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 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 shall be returned to the Contractor without review for resubmittal.
- C. Shop drawings shall include but not be limited to:
 1. Product datasheets.
 2. Cable pulling calculations (if required).

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 CALCULATIONS

- A. The Contractor shall submit cable pulling calculations. These calculations, to be performed by a currently registered professional engineer in the State of New Jersey, shall define pulling tension and sidewall loading (sidewall bearing pressure values) for all installations of 600VAC, #1/0 conductors and larger or greater than 200 feet in length. Calculations for straight horizontal installations of 600VAC, #1/0 conductors and larger or 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. 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 indicated on the Drawings. Only one (1) manufacturer for each wire and cable type shall be permitted.
- B. The wire and cable manufacturer shall be ISO 9000 registered.

2.02 600 VOLT POWER WIRE AND CABLE

- A. 600 volt cable and wire shall consist of stranded, copper conductor with insulation rated XHHW-2, 90°C for dry locations and wet locations.
- B. Conductors shall be stranded copper per ASTM-B8 and B-33, and Class B or C stranding contingent on the size unless otherwise specified. The minimum size wire shall be No. 12 AWG.
- C. 600-volt individual power wire and cable shall be Okoseal-N as manufactured by the Okonite Company, Cerro Wire and Cable equivalent, Southwire Company equivalent with SIMPull jacket, or equivalent. Multi-conductor power cables shall be X-Olene FMR Okolon TP-CPE Type TC-ER Cable as manufactured by the Okonite Company, Cerro Wire and Cable equivalent, Southwire Company equivalent, or equivalent.

2.03 600 VOLT CONTROL CABLE

- A. 600-volt control cable shall consist of stranded, copper conductor with insulation rated XHHW-2, 90°C for dry locations and 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, Method 1, E2. Cables shall meet the requirements of IEEE-383.

- B. Conductors shall be stranded copper per ASTM B-8 and B-33, and Class B or C stranding contingent on the size unless otherwise specified. The minimum wire size shall be No. 14 AWG.
- C. 600-volt individual conductor control wire shall be Okoseal-N as manufactured by the Okonite Company, Cerro Wire and Cable equivalent, Southwire Company equivalent with SIMPull jacket, or equivalent. Multi-conductor control cable shall be X-Olene FMR Okolon TP-CPE Type TC-ER Cable as manufactured by the Okonite Company, Cerro Wire and Cable equivalent, Southwire Company equivalent, or equivalent.

2.04 LIGHTING AND RECEPTACLE WIRE AND CABLE

- A. The lighting and receptacle branch circuit wire shall consist of solid, copper conductors with insulation rated XHHW, 90°C for dry locations and wet locations.
- B. Conductors shall be solid copper per ASTM- B-33. The minimum size wire shall be No. 12 AWG.
- C. Lighting and receptacle cables and wire shall be Okoseal-N as manufactured by the Okonite Company, Cerro Wire and Cable equivalent, Southwire Company equivalent with SIMPull jacket, or equivalent.

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 for wet or dry locations.
- 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, Cerro Wire and Cable equivalent, Southwire Company equivalent, or equivalent.

2.06 SHIELDED VFD CABLE

- A. The cable shall be 600V/1000V rated, with stranded tinned copper conductors, shielded, suitable for use with Variable Frequency Drives. Cable shall be suitable for use in wet/dry locations, indoors and outdoors, in cable trays, in conduits, trenches, and in underground ducts and direct burial. The conductor shall be annealed stranded tinned copper per ASTM B3, B8, and B33.
- B. The conductor shall be annealed stranded tinned copper per ASTM B3, B8, and B33. The insulation shall be rated for 90 degrees Celsius operating temperature. The insulation material shall be XLPE with a XHHW-2 listing per UL 44. The insulated conductors shall be cabled together with three (3) symmetrically placed ground wires. The ground wires shall have a minimum circular mil area equivalent to one circuit conductor. Fillers shall be included as necessary to make the cable.

- C. The cabled assembly shall be shielded by applying helically a 5 mil copper tape. The shield shall provide 100% coverage over the assembly. All cables shall have a continuous overall outer sheath of Polyvinyl Chloride (PVC), suitable for 90°C use. The jacket shall be resistant to abrasion, rated for direct burial, sunlight resistant and flame resistant in accordance with UL 1277. Cable shall be as manufactured by Belden Wire and Cable, Okonite, General Cable, AmerCable, or equivalent.

2.07 CABLE PULLING LUBRICANTS

- A. Cable pulling lubricants shall be non-hardening type and approved for use on the type of cable installed. Lubricant shall be Yellow #77 by Ideal, Cable Gel by Greenlee, Poly-Gel by Gardner Bender, or equivalent.

PART 3 -- EXECUTION

3.01 600V CABLE INSTALLATION

- A. The cable and wires shall be installed as specified herein and indicated 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 equivalent.
- 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 CMCMUA prior to splicing. Splicing materials shall be barrel type butt splice connectors and heat shrink tubing as manufactured by 3M, Ideal, or equivalent. No splicing of instrumentation cable shall be allowed. The use of screw-on wire connectors (wire nuts) shall only be permitted for lighting and receptacle circuits. Reference Section 16130 for additional requirements regarding control wiring.
- E. Wire and Cable Sizes
 - 1. The sizes of wire and cable shall be as indicated on the Drawings, or if not shown, as approved by the CMCMUA. If required due to field routing, the size of conductors and respective conduits shall be increased so that the voltage drop measured at the load 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 CMCMUA. The addition of conductors shall be coordinated with and approved by the CMCMUA to avoid violations of the NEC regarding conduit fill.

3. All spare conductors shall be terminated on the terminal blocks mounted within the equipment.

G. Wiring Identification

1. In addition to color-coding, all wiring shall be identified at each point of termination. This includes but is not limited to identification at the source, load, and in any intermediate junction boxes where termination is made. The Contractor shall meet with the CMCMUA to come to an agreement regarding a wire identification system prior to installation of any wiring. Wire numbers shall not be duplicated.
2. Wire identification shall be by means of a heat-shrinkable sleeve. Sleeves shall have a white background with black text. Wire sizes #14 AWG through #10 AWG shall have a minimum text size of 7 points. Wire sizes #8 AWG and larger shall have a minimum text size of 10 points. Sleeves shall be of appropriate length to fit the required text. The use of handwritten text for wire identification shall not be permitted.
3. Sleeves shall be suitable for the size of wire on which they are installed. When installation is complete, sleeves shall be tightly affixed to the wire and shall not move. Sleeves shall be heat shrunk onto wiring with a heat gun approved for the application. Sleeves shall not be heated by any means which employs the use of an open flame. The Contractor shall take special care to ensure that the wiring insulation is not damaged during the heating process.
4. Sleeves shall be installed prior to the completion of the wiring terminations and shall be oriented so that they can be easily read.
5. Sleeves shall be white polyolefin as manufactured by Brady, Seton, Panduit, or equivalent.
6. Where sleeves are not available in the size required for the wire, the Contractor shall use an adhesive label with a white background and black text. Text size shall be in accordance with the requirements listed above.
7. Adhesive labels, for the case when sleeves are not suitable for the wire size, shall be white permanent vinyl as manufactured by Brady, Seton, Panduit, or equivalent and suitable for the environment.
8. Wire identification in manholes, handholes, pull boxes, and other accessible components in the raceway system where the wiring is continuous shall be accomplished by means of a tag installed around the bundled group of conductors. Identification shall utilize a FROM-TO system. Each group of conductors shall consist of all of the individual conductors in a single conduit or duct. The tag shall have text that identifies the bundle in accordance with the 'FROM' and 'TO' column for that particular conduit number in the conduit and wire schedule. The minimum text size shall be 10 point. The tag shall be affixed to the wire bundle by the use of

nylon wire ties, and shall be made of polyethylene as manufactured by Brady, Seton Panduit, or equivalent.

H. Cable Installation

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

I. Wiring Supplies

1. Only electrical wiring supplies manufactured under high standards of production and meeting the approval of the CMCMUA 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.

J. 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 separately 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. The training shall be done in such a manner as to minimize chafing.

K. 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 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.

L. Pulling Temperature

1. Cable shall not be flexed or pulled when the temperature of the jacket is such that damage will occur due to low temperature embrittlement. When cable will be pulled with an ambient temperature of 40°F or less, the cable reels shall be stored three (3) days prior to pulling in a protected storage area with an ambient temperature of 55°F or more. Cable pulling shall be completed during the work day for which the cable is removed from the protected storage. Any remaining cable reels shall be returned to storage at the completion of the workday.

M. Color Coding

- 1. Conductor insulation shall be color coded as follows:**
 - a. 480/277V AC Power**
 - Phase A - BROWN
 - Phase B - ORANGE
 - Phase C - YELLOW
 - Neutral - GREY
 - 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 in accordance with the requirements listed above.**
- 3. Low voltage feeder and branch circuit conductors shall be identified in accordance with the NEC. The method utilized for conductor identification for each nominal voltage system shall be permanently posted at each feeder or branch circuit distribution equipment assembly. Reference Articles 200, 210, and 215 of the NEC.**

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 PVC conduit shall not be permitted. Analog signal wires shall exclusively occupy these conduits. No other wiring for AC or discrete DC circuits shall be installed in these conduits.
- B.** All shielding shall be continuous and shall be grounded at one point only, or in accordance with the instrumentation equipment manufacturer's recommendations.
- C.** Where instrumentation cables are installed in panels, manholes, hand holes, 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 the same bundle with conductors of other circuits.
- D.** Additional pull boxes shall be furnished and installed for ease of cable pulling and the cable manufacturer's recommended conduit fill factor shall be followed. Where required or specifically directed by the CMCMUA, the Contractor shall moisture seal the cables at all connections with OZ Gedney Type "CSB", or equivalent, sealing bushings.
- E.** Special instrument cable shall be as specified or recommended by the manufacturer of the equipment or instruments requiring such wiring. Installation, storage, terminations, etc., shall be per manufacturer's recommendations.
- F.** All cable insulation and jackets shall have adequate strength for it to be pulled through the conduit systems. All conductors shall be color-coded and all wires shall be suitably tagged with permanent markers as specified herein.

(END OF SECTION)

SECTION 16130

BOXES

PART 1 -- GENERAL

1.01 THE REQUIREMENT

- A. The scope of work under this Section includes furnishing and installing all pull boxes, junction boxes, and outlet boxes.
- B. Requirements for other boxes and enclosures are not included in this Section. Reference each specific Division 16 equipment Section for requirements related to that equipment's respective enclosure.
- C. Reference Section 16000, Basic Electrical Requirements, and Section 16111, Conduit.

1.02 CODES AND STANDARDS

- A. Boxes shall be designed, manufactured, and/or listed to the following standards as applicable:
 - 1. UL 514A - Metallic Outlet Boxes
 - 2. UL 514C - Standard for Non-metallic Outlet Boxes, Flush Device Boxes, and Covers
 - 3. UL 50 – Enclosures for Electrical Equipment, Non-Environmental Considerations
 - 4. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations
 - 5. UL 1203 – Standard for Explosion-proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations.
 - 6. NEMA 250 – Enclosures for Electrical 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 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 shall be returned to the Contractor without review for resubmittal.
- C. Shop drawings shall include but not be limited to:
 - 1. Product datasheets for boxes, terminal strips, and all accessories

1.05 OPERATION AND MAINTENANCE MANUALS

- A. The Contractor shall submit operation and maintenance manuals in accordance with the procedures and requirements set forth in the General Conditions and Division 1.
- B. As-built drawings showing dimensions, internal box layout, terminal strip information, and terminal strip identification information shall be provided for all junction boxes. As-built drawings are not required for pull boxes or outlet boxes.

1.06 IDENTIFICATION

- A. Each pull and junction box shall be identified with the box name as indicated on the Contract Drawings or as directed by the CMCMUA. A nameplate shall be securely affixed in a conspicuous place on each box. Nameplates shall be as specified in 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.

2.02 PULL AND JUNCTION BOXES

A. General

- 1. All pull and junction boxes shall be UL listed and labeled.
- 2. Pull and junction boxes shall not be provided with eccentric or concentric knockouts.
- 3. Pull and junction boxes mounted embedded in concrete shall be UL listed for embedment.
- 4. Where metallic boxes are used they shall be of all-welded construction. Tack welded boxes shall not be acceptable.

B. Pull Boxes

- 1. All pull boxes shall be provided with a matching gasketed cover. For covers with dimensions of 24 inches by 24 inches or less, the cover shall be held in place by machine screws. Other screw types shall not be acceptable. For covers with dimensions greater than 24 inches by 24 inches, the cover shall be hinged and

held in place by screw-operated clamp mechanisms. Hinge pins shall be removable. Clamp mechanism material of construction shall match that of the associated box.

2. Pull boxes shall not have any wire terminations inside, other than those for grounding/bonding. A ground bar shall be provided with the necessary number of screw-type terminals. Twenty (20) percent of the total amount of terminals otherwise required for the pull box (minimum of two) shall be provided as spare terminations. Boxes requiring any other wire terminations shall be furnished and installed in accordance with the requirements for junction boxes herein.
3. Pull boxes shall be 6 inches wide by 6 inches tall by 4 inches deep, minimum. For applications requiring larger boxes, the box shall be sized in accordance with the fill requirements and dimensional requirements of the NEC.
4. Barriers shall be provided in pull boxes to isolate conductors of different voltages, types, and functions. Barrier material of construction shall match that of the box. Isolation shall be provided between the following groups:
 - a. Power wiring
 - b. AC control wiring
 - c. DC control wiring
 - d. Instrumentation wiring

C. Junction Boxes

1. Junction boxes used for lighting and receptacle circuits only shall be provided with a matching gasketed cover held in place by machine screws. Other screw types shall not be acceptable.
2. Junction boxes for all uses other than lighting and receptacle circuits shall be provided with a hinged, gasketed cover. Hinge pins shall be removable. Cover shall be held in place by screw-operated clamp mechanisms. Clamp mechanism material of construction shall match that of the associated box.
3. Barriers shall be provided in junction boxes to isolate conductors and terminal blocks of different voltages, types, and functions. Barrier material of construction shall match that of the box. Isolation shall be provided between the following groups:
 - a. Power wiring
 - b. AC control wiring
 - c. DC control wiring
 - d. Instrumentation wiring

4. Junction boxes used for lighting and receptacle circuits only shall be allowed to have screw-on (wire nut) type connectors for wire terminations/junctions.
5. Junction boxes for all uses other than lighting and receptacle circuits shall be provided with terminal strips, consisting the necessary number of screw-type terminals. Current carrying parts of the terminal blocks shall be of ample capacity to carry the full load current of the circuits connected, with a 10A minimum capacity. Terminal strips shall be rated for the voltage of the circuits connected. A separate ground bar shall be provided with the necessary number of screw type terminals. Twenty (20) percent of the total amount of terminals otherwise required for the junction box (minimum of two) shall be provided as spare terminations. When barriers are provided within the box, separate terminal strips shall be provided in each barrier area. Terminals shall be lettered and/or numbered to conform to the wiring labeling scheme in place on the project.
6. Junction boxes shall be 6 inches wide by 6 inches tall by 4 inches deep, minimum. For applications requiring larger boxes, the box shall be sized in accordance with the fill requirements and dimensional requirements of the NEC. Terminal blocks (including spare terminals) shall be considered when sizing the junction box.

D. Enclosure Types and Materials

1. In non-hazardous locations, pull and junction boxes shall be furnished with the following enclosure type and material of construction, dependent upon the designation of the area in which they are to be installed. Area designations are indicated on the Drawings.

AREA DESIGNATION	ENCLOSURE TYPE AND MATERIAL
Indoor Wet Process Area	NEMA 4X, Type 304 Stainless Steel
Indoor Dry Process Area	NEMA 12, Painted Steel
Indoor Dry Non-Process Area	NEMA 1, Painted Steel
All Outdoor Areas	NEMA 4X, Type 304 Stainless Steel

2. Non-metallic enclosures, NEMA 7 enclosures, and NEMA 9 enclosures shall be provided with threaded integral conduit hubs.

2.03 OUTLET BOXES

A. General

1. Outlet boxes shall be provided with a trim appropriate for the wiring device installed inside. Reference Section 16141, Wiring Devices, for outlet box trim requirements. An appropriate outlet box trim is required to achieve the NEMA rating of the outlet boxes as specified herein.

B. Surface Mount Outlet Boxes

1. Outlet boxes shall be the deep type, no less than 2.5 inches deep.
2. Outlet boxes shall be provided in a single or multi-gang configuration as required, sized in accordance with the requirements of the NEC.

3. In non-hazardous locations, outlet boxes shall be furnished with the following enclosure type and material of construction, dependent upon the designation of the area in which they are to be installed. Area designations are indicated on the Drawings.

AREA DESIGNATION	ENCLOSURE TYPE AND MATERIAL
Indoor Wet Process Area	NEMA 4X, Cast Aluminum
Indoor Dry Process Area	NEMA 1, Cast Aluminum
Indoor Dry Non-Process Area	NEMA 1, Cast Aluminum
All Outdoor Areas	NEMA 4X, Cast Aluminum

4. Outlet boxes shall be provided with integral threaded conduit hubs mounted external to the box. Boxes with threaded conduit hubs mounted internally to the box or as a part of the box wall shall not be acceptable.

C. Flush Mount Outlet Boxes

1. Outlet boxes shall be no less than 2-1/8 inches deep, and 4-11/16 inches square. Boxes shall be UL listed and labeled. Pre-punched single diameter conduit knockouts are acceptable, however, concentric and eccentric knockouts shall not be acceptable.
2. Outlet boxes mounted flush in CMU walls shall be made of galvanized, tack welded steel, and suitable for installation in masonry walls. Sectional type boxes shall not be acceptable for this application.
3. Outlet boxes mounted flush in gypsum walls shall be made of galvanized pressed steel. Tack welded boxes shall not be acceptable for this application. Sectional type boxes shall not be acceptable for this application.
4. Outlet boxes mounted cast into concrete shall be concrete tight, and shall be made of galvanized steel or PVC.

PART 3 -- EXECUTION

3.01 INSTALLATION

A. Pull and Junction Boxes

1. Pull boxes and junction boxes shall be solidly attached to structural members prior to the installation of conduit and set true and plumb. Boxes shall not be supported by their associated conduits.
2. Wooden plugs shall not be permitted for securing boxes to concrete. Appropriately rated anchors specifically suited for use in concrete shall be used.
3. Box penetrations for conduits shall be made with a punch tool, and penetrations shall be of the size required for the conduit entry and/or hub. Oversized penetrations in boxes shall not be acceptable.

4. Watertight conduit hubs shall be provided for boxes where a NEMA 4X enclosure rating is specified. Reference Section 16111, Conduit, for conduit hub requirements.
5. Pull and junction boxes may be installed flush-mounted in gypsum, concrete or CMU walls where appropriate provided that covers are easily removed or opened.
6. Pull and junction boxes shall be provided in the enclosure type and material of construction required for the area in which it is installed. Reference the requirements in Part 2 herein, and the area designations indicated on the Drawings.

B. Outlet Boxes

1. Outlet boxes shall be solidly attached to structural members prior to the installation of conduit and set true and plumb. Boxes shall not be supported by their associated conduits.
2. Wooden plugs shall not be permitted for securing boxes to concrete. Appropriately rated anchors specifically suited for use in concrete shall be used.
3. Flush mounted outlet boxes shall be arranged and located so that tile and grout lines fit closely around the boxes, and so placed that the cover or device plate shall fit flush to the finished wall surface.
4. Outlet boxes shall be flush mounted in finished areas and other areas where practical. Flush mounted outlet boxes shall not be installed in hazardous areas and type 1 or 2 chemical storage/transfer areas.
5. For the below-named items, mounting heights from finished floor, or finished grade to top is applicable, depending on the type of wiring device to be installed in the outlet box. Mounting heights for outlet boxes shall be as follows unless otherwise specified herein, indicated on the Drawings, or required by the Americans with Disability Act (ADA):
 - a. Light switches and wall mounted occupancy sensors, 48 inches
 - b. Receptacles in indoor dry process/non-process areas, 16 inches
 - c. Receptacles in indoor wet process areas and all indoor chemical storage/transfer areas, 48 inches
 - d. Receptacles in outdoor locations, 24 inches
 - e. Ceiling mounted occupancy sensors, as indicated on the Drawings
6. Outlet boxes shall be provided in the material of construction required for the area in which it is installed. Reference the requirements in Part 2 herein, and the area designations indicated on the Drawings.

(END OF SECTION)

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 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 CMCMUA.
- 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 CODES AND STANDARDS

- A. Equipment and materials covered under this Section shall be designed, manufactured, and/or listed to the following standards as applicable:
 - 1. UL 467 – Grounding and Bonding Equipment
 - 2. IEEE 81 – Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System.

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 shall be returned to the Contractor without review for resubmittal.

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

1. Product data sheets.

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). The rods 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. Ground rods shall be UL 467 listed. The ground rods shall be manufactured by Erico Products, Blackburn, or equivalent.
- B. 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 ground grid surrounding the structure. The ground grid shall also be connected 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.
- 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 shall be made by hydraulic crimp or exothermically welded. Split-bolt type connectors shall not be acceptable. Fittings shall be UL 467 listed.

2.04 EQUIPMENT GROUNDING CONDUCTORS

- A. An insulated equipment grounding conductor, which shall be separate from the electrical system neutral conductor, shall be furnished and installed for all circuits. Insulation shall be of the same type as the underground conductors in the raceway and shall be green in

color. Equipment grounding conductors shall be furnished and installed in all conduits. Use of conduits as the NEC required equipment grounding conductor shall not be 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.

2.06 EXOTHERMIC WELDS

- A. All exothermic welding shall be completed per welding kit manufacturer's instructions. Exothermic welds shall be CadWeld by Erico or ThermoWeld, or equivalent.

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 as shown on the Drawings. The ground rods shall be interconnected by the use of copper cable exothermically welded to the rods. 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 "pigtailed" shall be connected to the ground grid 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. The copper pigtailed shall be exothermically welded to the ground grid, and connected to building reinforcement steel by hydraulic crimp.
 - 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. 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.

5. Buried exothermic welds and ground ring shall not be backfilled until inspected by CMCMUA.

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.

D. PLC Enclosure

1. Single point grounding shall be used in all PLC Enclosure Assemblies.

3.02 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 NETA Acceptance Testing Specifications, latest edition.
- b. Fall-of-Potential tests shall be performed on the ground grid per IEEE81 recommendations by a third party, independent testing firm. A fall of potential plot shall be submitted at the conclusion of testing for CMCMUA review. Documentation indicating the location of the rod and grounding system as well as the resistance and soil conditions at the time the measurements were made shall be submitted. Testing shall show that the ground grid has 5 ohms resistance or less. Due to soil conditions and/or unforeseen field conditions, ground resistances greater than 5 ohms may only be accepted if specifically approved in writing by the CMCMUA. Ground resistance measurements shall be made in normally dry weather not less than 48 hours after rainfall and with the ground grid under test isolated from other grounds.
- c. Continuity tests for the grounding electrode conductor shall also be performed. Test shall be accepted when a resistance of less than 1 ohm is shown for this conductor.

(END OF SECTION)

SECTION 16190
SUPPORTING DEVICES

PART 1 -- GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish and install structural supports for mounting and installing all conduit, electrical equipment, 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 the following:
 - 1. Shop drawings
 - 2. Structural support calculations (if required)
- B. 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 submittal shall be returned to the Contractor without review for resubmittal.
- C. Shop drawings shall include but not be limited to:
 - 1. Product datasheets.
 - 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. Support channel shall be 1-5/8" by 1-5/8" minimum, with 12-gauge material thickness.
- B. Support channel, support channel fittings, and threaded rod shall be furnished with the following material of construction, dependent upon the designation of the area in which they are to be installed. Area designations are indicated on the Drawings.

AREA DESIGNATION	MATERIAL OF CONSTRUCTION
Indoor Dry Non-Process Area	Type 304 Stainless Steel
All Outdoor Areas	Type 304 Stainless Steel

- C. Fastening hardware (bolts, nuts, washers, and screws) shall be furnished with the following material of construction, dependent upon the designation of the area in which they are to be installed. Area designations are indicated on the Drawings.

AREA DESIGNATION	MATERIAL OF CONSTRUCTION
Indoor Dry Non-Process Area	Type 304 Stainless Steel
All Outdoor Areas	Type 304 Stainless Steel

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 CMCMUA, 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 channels for all switchgear, switchboards, motor control centers, and similar floor-mounted equipment. The leveling channels shall be provided for embedment in the equipment housekeeping pads. Coordination of the installation of these channels with the concrete pad is essential and required. Pad height shall be as required to maintain concrete coverage of the reinforcement bars while not causing associated equipment to exceed the maximum mounting height 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.

2. All holes made in reflected ceilings for support rods, conduits, and other equipment shall be made adjacent to ceiling grid bars where possible, to facilitate removal of ceiling panels.
3. Support channel shall be provided wherever required for the support of starters, switches, panels, and miscellaneous equipment.
4. All equipment, devices, and raceways that are installed on the dry side of a water-bearing wall shall not be installed directly onto the wall. Support channel shall be used to allow ventilation air to pass behind the equipment, devices, or raceway.
5. 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.
6. 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.
7. Actual designs for supporting framework should take the nature of a picture frame of support channels and bracket with a plate for mounting the components. The Contractor is responsible for the design of supporting structure; the Contractor shall submit design details to the CMCMUA for acceptance before proceeding with the fabrication.
8. Wherever dissimilar metals come into contact, the Contractor shall isolate these metals as required with neoprene washers, nine (9) mil polyethylene tape, or gaskets.
9. For all installations where fiberglass supporting materials are required, the Contractor shall submit structural calculations and the details of the proposed system of support. Structural calculations shall be signed and sealed by a registered professional engineer in the State of New Jersey
10. For the following installations where conduits are provided with a support system suspended from the above or attached to a vertical structure, the Contractor shall submit structural calculations and details of the proposed system of support. Structural calculations shall be signed and sealed by a registered professional engineer in the State of New Jersey
 - a. A quantity of twelve (12) or more conduits trade size 1" and smaller are proposed for a conduit support rack.
 - b. A quantity of eight (8) or more conduits trade sizes 1 ½" to 2 1/2" are proposed for a conduit support rack.
 - c. A quantity of four (4) or more conduits trade sizes 3" and larger are proposed for a conduit support rack.
11. Where supports are needed to be embedded into pre-stressed concrete ceiling, approval of embed locations shall be obtained by the CMCMUA in order to avoid breaking the steel wires in the ceiling.

(END OF SECTION)

SECTION 16195

ELECTRICAL - IDENTIFICATION

PART 1 -- GENERAL

1.01 THE REQUIREMENT

- A. All electrical equipment shall be properly identified in accordance with these Specifications and the Contract Drawings. All switchgear, switchboards, motor control centers, variable frequency drives, lighting and distribution panelboards, combination starters, control panels, pull and junction boxes, enclosures, disconnect switches, control stations, and similar equipment shall be identified in the manner described, or in an equally approved manner.
- B. The types of electrical identification specified in this section include, but are not limited to, the following:
 - 1. Operational instructions and warnings.
 - 2. Danger signs.
 - 3. Equipment/system identification signs.
 - 4. Nameplates.

1.02 SIGNS

- A. "DANGER-HIGH-VOLTAGE" signs shall be securely mounted on the entry doors of all electrical rooms.

1.03 LETTERING AND GRAPHICS

- A. The Contractor shall coordinate names, abbreviations, and other designations used in the electrical identification work with the corresponding designations shown, specified or scheduled. Provide numbers, lettering, and wording as indicated or, if not otherwise indicated, as recommended by manufacturers or as required for proper identification and operation/maintenance of the electrical systems and equipment.

1.04 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. Product data sheet for each type of Electrical Identification provided under this contract.
 - 2. Samples for each type of Electrical Identification provided under this contract.

1.05 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 shall be returned to the Contractor without review for resubmittal.
- C.** Shop drawings shall include but not be limited to:
 - 1.** Product datasheets.

PART 2 -- PRODUCTS

2.01 MANUFACTURERS

- A.** The material covered by these Specifications 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 NAMEPLATES

- A.** Nameplates shall be engraved, high-pressure plastic laminate, white with black lettering.
- B.** Nameplates shall be attached to NEMA 4X enclosures utilizing UL-recognized mounting kits designed to maintain the overall UL Type rating of the enclosure. Mounting kit fasteners shall be stainless steel Type AHK10324X as manufactured by Hoffman, or equivalent.

2.03 HIGH VOLTAGE SIGNS

- A.** Standard "DANGER" signs shall be of baked enamel finish on 20 gauge steel; of standard red, black and white graphics; 14 inches by 10 inches size except where 10 inches by 7 inches is the largest size which can be applied where needed, and except where a larger size is needed for adequate identification.

2.04 CONDUIT IDENTIFICATION

- A.** Conduit identification shall be as specified in Section 16111, Conduit.

2.05 WIRE AND CABLE IDENTIFICATION

- A.** Field-installed wire and cable identification shall be as specified in Section 16123, Building Wire and Cable.
- B.** A plastic laminate nameplate shall be provided at each panelboard, motor control center, switchgear assembly, and switchboard assembly. This nameplate shall be used to clearly convey the conductor identification means used at that piece of equipment (i.e. Phase A=Brown, Phase B=Orange, Phase C = Yellow).

- C. Wiring identification for factory-installed wiring in equipment enclosures shall be as specified in the respective section.

2.06 BOX IDENTIFICATION

- A. Pull, junction and device box identification shall be as specified in Section 16130 – Boxes.

PART 3 -- EXECUTION

3.01 NAMEPLATES

- A. Nameplates shall be attached to the equipment enclosures with (2) two stainless steel sheet metal screws for nameplates up to 2-inches wide. For nameplates over 2-inches wide, four (4) stainless steel sheet metal screws shall be used, one (1) in each corner of the nameplate. The utilization of adhesives shall not be permitted.

3.02 OPERATIONAL IDENTIFICATION AND WARNINGS

- A. Wherever reasonably required to ensure safe and efficient operation and maintenance of the electrical systems and electrically connected mechanical systems and general systems and equipment, including prevention of misuse of electrical facilities by unauthorized personnel, install plastic signs or similar equivalent identification, instruction, or warnings on switches, outlets, and other controls, devices, and covers or electrical enclosures. Where detailed instructions or explanations are needed, provide plasticized tags with clearly written messages adequate for the intended purposes. Signs shall be attached as specified above for nameplates.

3.03 POWER SOURCE IDENTIFICATION

- A. After installation of all field equipment (i.e. valves, motors, fans, unit heaters, instruments, etc.) install nameplates at each power termination for the field equipment. Nameplate data shall include equipment designation (tag number), power source (MCC number, panelboard, etc), circuit number, conduit number from schedule and voltage/phase.
- B. Contractor to coordinate with the CMCMUA regarding exact nameplate placement during construction.
- C. Nameplates shall be as specified herein.

(END OF SECTION)

SECTION 16482

MOTOR CONTROL CENTERS MODIFICATIONS

PART 1_GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall modify, test, and place in satisfactory operation, the motor control centers as specified herein and indicated on the Drawings.
- B. The motor control center modification includes, but is not limited to, rewiring of the control circuits to isolate the 120VAC from going to the PLC via run command relays, and installing three position Hand Off Auto and On Off selector switches on the MCC doors.
- C. Motor control circuits shall be wired in accordance with the requirements specified herein or indicated on the Drawings. Where not indicated, the control circuits shall be standard three-wire "start-stop" and the Contractor shall furnish wiring accordingly.
- D. Reference Section 16000, Basic Electrical Requirements; Section 16195, Electrical Identification; Section 16461 - and Section 16902, Electric Controls and Relays.

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. Field Tests
 - a. Submit description of proposed testing methods, procedures, and apparatus.
 - b. Submit notarized and certified copies of all field test reports.
 - c. As a minimum, the existing MCC assembly shall go through a quality inspection. This inspection shall include, but is not limited to, the following:
 - i. Physical inspection of the structure and the electrical conductors including bussing, general wiring, and units.
 - ii. General electrical tests including power circuit phasing, control circuit wiring, instrument transformers, meters, ground fault system, and device electrical operation.
 - iii. AC dielectric tests of the power circuits and control circuits.
 - iv. Markings/labels, including instructional type, Underwriters Laboratory (U.L.), and inspector's stamps.
 - d. Field tests shall be performed 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.
 - 3. Special Tools List.
 - 4. Proposed Testing Methods and Reports of Certified Shop and Field Tests.
 - 5. Operation and Maintenance Manuals.
- 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 shall be returned to the Contractor without review for resubmittal.
- C. Shop drawings for MCC to be modified shall include but not be limited to:
 - 1. Equipment specifications and product data sheets identifying all materials used and methods of fabrication.
 - 2. Example equipment nameplate datasheet.
 - 3. Internal schematic and point-to-point wiring diagrams of each compartment of the motor control center being modified include installation of starters, breakers and bus taps. Each wiring diagram shall include wire identification and terminal numbers as traced out in the field. Indicate all devices, regardless of their physical location, on the diagrams. Identify on each respective wiring diagram specific equipment names and equipment numbers consistent with those indicated on the Drawings.
 - 4. Complete single-line diagrams showing all modifications and additions showing circuit breakers, motor circuit protectors, motor starters, instrument transformers, meters, relays, timers, control devices, dry-type transformers, panelboards, and other equipment comprising the complete assembly. Indicate electrical ratings of equipment and devices on these single-line diagrams. Ratings include starter size and type, circuit breaker frame size and trip rating, transformer ratings, panelboard ratings, motor horsepower, and full load current, and similar information.
 - 5. Bill of material list for each motor control center and each motor control unit.

6. Nameplate schedule for each section to be modified.
 7. Manufacturer's installation instructions.
 8. Time-current curves for each type and size protective device if requested by the CMCMUA.
- D. The shop drawing information shall be complete and organized in such a way that the CMCMUA can determine if the requirements of these Specifications are being met. Copies of technical bulletins, technical datasheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items the Contractor intends to provide are acceptable and shall be submitted.
- E. Prior to completion and final acceptance of the project, the Contractor shall furnish and install "as-built" wiring diagrams for each MCC unit of each motor control center. These final drawings shall be plastic laminated and securely placed inside each MCC unit door and included in the O&M manuals.

1.05 OPERATION AND MAINTENANCE MANUALS

- A. The Contractor shall submit operation and maintenance manuals in accordance with the procedures and requirements set forth in the General Conditions and Division 1.

1.06 IDENTIFICATION

- A. Each motor control center shall be identified with the identification number indicated on the Drawings. A nameplate shall be securely affixed in a conspicuous place on each motor control center. Nameplates shall be as specified in Section 16195, Electrical - Identification.

1.07 CONSTRUCTION SEQUENCING

- A. The Contractor shall reference Section 01520, Maintenance of Utility Operations During Construction, of these Specifications.

PART 2 -- PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturer and Model No. of the existing motor control center to be modified is indicated on the drawing.

2.02 MOTOR CONTROL CENTER

A. General

1. The motor control centers shall be capable of withstanding the fault current available at its line terminals as determined by the Contractor's short circuit study which includes the new loads as indicated on contract drawing.

2. Continuous horizontal wiring troughs shall be provided at both the top and bottom of each section being modified.
3. All control wiring shall be No. 14 AWG (minimum) labeled at each end in accordance with the wiring numbers shown on the accepted shop drawings. Power wiring shall be sized to suit the maximum horsepower rating of the unit; No. 12 AWG (minimum). Wiring shall be type TEW rated for 105°C. Wire color coding shall be as specified in Section 16195, Electrical-Identification, of these Specifications. Wire numbers shall not be repeated in a motor control center.
4. The motor control centers shall be furnished with warning signs to notify maintenance personnel of multiple sources of power within the motor control units. Reference Article 430-74 of the NEC.

B. Incoming Line Units

1. Each incoming line unit shall be modified as shown on contract drawings. All required cable lugs shall be suitable for their respective conductors and proper function modification.

C. The Unit Compartments

1. Each unit compartment shall be provided with an individual front door hinged to the vertical structure. Each plug-in unit shall be supported and guided by a removable unit support pan, so that the unit rearrangement is easily accomplished. The rearrangement of the unit support pan from one location to the other shall be accomplished without use of tools. After insertion, each plug-in unit shall be held in place by at least two multi-turn latches, located at the front of the unit. At least one latch shall be located at the top of the insert and one at the bottom, for front accessibility and installation convenience.
2. The unit plug-in power stabs shall be electromagnetically tin-plated copper to yield a low resistance connection and designed to tighten during heavy current surges and short circuits. The stab shall be backed by spring steel clips to provide and maintain a high pressure, two-point connection to the vertical bus. They shall be free-floating and self-loading plug-in. Wiring from the unit disconnecting means to the plug-in stab shall be exposed at the rear of the unit. The power cable terminations at the plug-in stab shall be mounted in a two-piece, glass polyester support assembly. This support assembly shall provide a separate isolated pathway for each phase, minimizing the probability of a unit fault condition reaching the power bus system.
3. An industrial, heavy-duty flange handle mechanism shall be supplied for the control of each disconnecting means. This mechanism shall be engaged with the disconnect device at all times as an integral part of the unit regardless of the unit door position. The operator handles shall have an up-down motion with the down position as off. The ON-OFF condition of the disconnecting means shall be permanently marked on the handle operator. It shall be possible to lock the handle in the "OFF" position with up to three (3) 3/8 inch diameter shackle padlocks and in the "ON" position with one (1) 3/8 inch diameter shackle padlock.

4. The operator handle of all units shall be interlocked with the door units so that the disconnect means cannot be switched unless the door unit is closed. A means shall be provided for purposely defeating the interlock during maintenance or testing. This interlock shall also prevent opening the unit door unless the disconnecting means is in the off position. An externally operated def eater requiring the use of a screwdriver shall provide access to the unit without interrupting service.

D. Isolation and Insulation

1. Horizontal bus access covers and vertical bus covers shall isolate the energized buses to guard against the hazard of accidental contact. These covers shall be molded of a glass polyester material.
2. The horizontal bus shall be isolated from the top horizontal wireway by a grounded steel barrier. This barrier shall be removable to allow access to the bus and connections for maintenance.
3. The vertical bus cover shall provide unit plug-in openings which shall permit unit plug-in stab assemblies to pass through and engage the vertical bus. The unit plug-in openings shall be sized to minimize the probability of inadvertent contact with the vertical bus.
4. Isolation of unused stab openings shall be accomplished by the use of a manual shutter to close off the stab opening. These shutters shall be attached to the structure so that when they are removed (to allow a stab connection) they are retained in the structure and are readily accessible for use should a plug-in unit be removed from the motor control center.
5. All units shall be isolated from one another, above and below, by unit support pans or steel barriers, which can remain in place when the units are withdrawn.
6. Incoming line compartments shall be isolated from horizontal and vertical wireways by steel barriers.
7. Unit to vertical wireway isolation shall be available as a molded unit isolating barrier.

E. Circuit Breakers

1. Where specified herein, indicated on the Drawings, or required, the main circuit breaker shall be rated for service entrance and bear service entrance label.
2. Unless otherwise indicated, circuit breakers shall be manually operable and shall provide thermal-magnetic, inverse-time-limit overload, and instantaneous, short-circuit protection.
3. Breakers shall be molded case type, rated 480 VAC, 2 or 3 pole, and have 100 ampere or larger frames. The minimum interrupting rating shall be 42,000A RMS symmetrical at 480V.

4. Overload protection shall be provided on all poles with trip settings as indicated on the Drawings. Breakers of 225-ampere frames and larger shall have interchangeable trip units and adjustable magnetic trip elements.
5. Time-current characteristic curves and other necessary information and data for each size of breaker furnished shall be provided in the Submittal if requested by the CMCMUA.
6. Shunt trip devices shall be provided to trip a circuit from a remote location by means of a trip coil energized from a separate circuit. A 120V shunt trip shall be capable of operating 55% or more of rated voltage. All other shunt trips shall be capable of operating at 75% or more of rated voltage.

F. Terminal Blocks

1. Terminal blocks shall be mounted within the unit insert and in the front for accessibility. Control terminal blocks shall be pull-apart style; Type K - NEMA terminal block as manufactured by Square D Company, Buchanan, General Electric Company, or equivalent.
2. The pull-apart terminal block assembly shall consist of a male and female component held together with captive screws. The terminal block assembly shall be designed to withstand the effects of vibration, yet able to be pulled apart without difficulty. The terminals of the assembly shall be recessed to isolate them from accidental contact. Terminal markings shall be provided for the purpose of identifying terminations.
3. Provide with a minimum of 25 percent spare terminals.

G. Nameplates

1. The motor control centers shall be furnished complete with engraved phenolic nameplates for each MCC and each unit compartment. Circuit numbers and equipment names and numbers as indicated on the single line diagrams shall be used as the basis to engrave the nameplates. Nameplates shall be as specified in Section 16195, Electrical-Identification.

H. Motor Control Center Additions and Modifications

1. These additions and modifications specified herein shall be of the same manufacturer, type, rating, and color as the existing motor control centers. Furnish and install all hardware necessary to connect the buses of the new and existing MCCs, including ground buses. Enclosures shall match existing.

PART 3 -- EXECUTION

- A. Refer to Section 16000 for additional requirements.

(END OF SECTION)

SECTION 16902

ELECTRIC CONTROLS AND RELAYS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

- A. The Contractor shall furnish, install, test, and place in satisfactory operation all electric controls and relays as specified herein and indicated on the Drawings.
- B. Electrical control and relay systems shall be assembled using Schneider Electric 782 Power Series Relays with full-feature cover and needs to be UL rated components, part number 782XBXM4L-XXX. Mounting base will be din or panel mount with screw terminations part number 70-782D8-1A with plastic hold-down retaining clip part number 16-782PC-1
- C. Motor control circuits shall be wired in accordance with the requirements specified herein or indicated on the Drawings.
- D. Reference Section 16000, Basic Electrical Requirements and Section 16195, Electrical Identification.
- E. The Contractor shall furnish and install, as specified herein and indicated on the Drawings, all motor control components and wiring for all motor-operated equipment furnished under this Section and all other Sections as indicated. The Contractor shall review the entire Contract Documents to be totally familiar with the Contractor's responsibilities.
- F. The Contractor shall furnish and install all external power and control wiring to control panels of prewired packaged equipment, unless indicated otherwise.
- G. Control wiring requirements are indicated in electrical schematics and descriptions on the Drawings, and in equipment manufacturer's equipment data. The Contractor shall furnish and install all control wiring in accordance with these Contract Documents. The Contractor shall provide all control circuits and wiring for a particular item of equipment in accordance with requirements as set forth by the manufacturer of the particular item of equipment.
- H. As specified herein and indicated on the Drawings, furnish and install instrumentation wiring and connections to instrumentation equipment. Unless indicated otherwise, motor control switches, pilot lights, relays, and other control equipment for mounting in instrumentation panels shall be furnished, installed, and wired by the Contractor.
- I. Where pumps provided by others are furnished with solenoid valves or other devices for control, the Contractor shall wire these valves or devices.
- J. Unless otherwise specified herein or indicated on the Drawings, motor controllers shall be wired to drop out and remain dropped out on loss of power to the line side of the controller. Operator action shall be required to restart the motor unless the motor is intended to automatically restart.
- K. Motor control components and control wiring shall conform to NEMA Specifications ICS-1970 (Revised, 1975), Industrial Controls and Systems.

- L. Where devices are installed on the doors of NEMA 4, 4X, or 3R enclosures, devices shall be selected and installed to maintain the NEMA rating of the enclosure.
- M. Wiring in all starters, panels, junction boxes, and similar equipment shall be brought out to numbered terminal strips for interconnection. The Contractor shall be responsible for documenting terminal numbers for all starters, controls, panels, and similar equipment provided under this Contract. At the completion of the project, the Contractor shall submit a complete set of record drawings showing and/or listing all terminals in boxes, panels, starters, and similar equipment in a single, complete bound package for the equipment and control supplied under this Contract. Reference the General Conditions, Section 01300 - Submittals and Section 01700 - Project Closeout.
- N. The Contractor is responsible for coordinating the electrical work under this Contract with all equipment starters, controls, and instruments provided by others. The Contractor shall verify and coordinate with process equipment power supply and voltage, process equipment control power supply and voltage, and details of installation and interconnection. Coordination shall include distribution of approved electrical shop drawings to the General Contractor's equipment suppliers.
- O. Electrical control schematic diagrams drawn using a ladder-type format in accordance with JIC standards shall be submitted for all electrical equipment which is being provided under this Contract.
- P. Record drawings shall be provided in accordance with requirements in the General Conditions, Section 01300 - Submittals, and Section 01700 - Project Closeout. One complete set of record wiring diagrams encased in plastic or plexiglass envelopes shall be provided for each starter, panel, and similar equipment. The diagrams shall include wire color codes showing connections from numbered terminal blocks to external equipment.
- Q. Where space or strip heaters are provided within the enclosures for electrical equipment, the Contractor shall make connections to these heaters from an appropriate power source and operate the heaters with temperature control as necessary until the equipment is installed and operated according to its intended use.
- R. Control stations shall be furnished and installed at each motor and at all other controlled devices (e.g. solenoid valves) as specified herein and indicated on the Drawings.

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 tests shall be performed 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. Operation and Maintenance Manuals.
- 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 shall be returned to the Contractor without review for resubmittal. The letter and performance affidavit described above must be included in the first submittal.
- C. Shop drawings shall include but are not limited to:
 - 1. Product datasheets.
- D. The shop drawing information shall be complete and organized in such a way that the CMCMUA 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 the Contractor intends to provide are acceptable and shall be submitted.

1.05 OPERATION AND MAINTENANCE MANUALS

- A. The Contractor shall submit operation and maintenance manuals in accordance with the procedures and requirements set forth in the General Conditions and Division 1.

1.06 TOOLS, SUPPLIES AND SPARE PARTS

- A. None

PART 2 -- PRODUCTS

2.01 POWER RELAYS (Heaters or Lighting Contactors)

- A. Enclosures

1. Saginaw 8" x 6" x 6" Part SCE-8066CHNF steel enclosure with backplane or approved equivalent.
 - a. 0.063 In. carbon steel.
 - b. Seams continuously welded and ground smooth, no holes or knockouts.
 - c. Continuous hinges with stainless steel hinge pins.
 - d. External screw clamps are quick and easy to operate.
 - e. Pour in place oil & water-resistant gasket.
 - f. 10-32 Standoffs provided for mounting optional panels.
 - g. Ground stud on door & body.
 - h. Welded mounting provision top and bottom of back.

A. Power Relay

2. Schneider TeSys D Contactor Part # LC1D18BD or approved equivalent.
 - a. 3P with 3NO Poles
 - b. Rated up to 690 VAC
 - a. 4 kW 220...230 V AC 50/60 Hz AC-3)
 - b. 7.5 kW 380...400 V AC 50/60 Hz AC-3)
 - c. 9 kW 415...440 V AC 50/60 Hz AC-3)
 - d. 10 kW 500 V AC 50/60 Hz AC-3)
 - e. 10 kW 660...690 V AC 50/60 Hz AC-3)
 - f. 4 kW 400 V AC 50/60 Hz AC-4)
 - g. 4 kW 220...230 V AC 50/60 Hz AC-3e)
 - h. 7.5 kW 380...400 V AC 50/60 Hz AC-3e)
 - i. 9 kW 415...440 V AC 50/60 Hz AC-3e)
 - c. Coil voltage 24 VDC
 - d. AUX contact 1 NO + 1 NC

2.02 CONTROL COMPONENTS

A. Pilot Devices

1. Pushbuttons (PB) and selector switches (SS) shall be Harmony Type 9001 SK as manufactured by Square D. Outdoor type PB and SS shall be 30.5 mm, heavy-duty, oil tight NEMA 4X corrosion resistant with legend plates as specified herein, indicated on the Drawings, or otherwise directed by the CMCMUA. Legend plates shall be plastic, black field (background) with white lettering. PB and SS shall be non-illuminated. PB shall include a full guard. Panic stop/alarm pushbuttons shall be red mushroom type with manual-pull release.
2. PB and SS for all electrical equipment shall be of the same type and manufacturer unless otherwise specified herein or indicated on the Drawings.
3. PB, SS, and other pilot devices for pump control panels shall be as specified herein and as shown on the Drawings.
4. Engraved nameplates shall be securely fastened to the front of each PB station, disconnect switch, and motor starter remotely located from the motor control center. If adequate space is not available, the nameplate shall be mounted below the push button station. Nameplates shall be as specified in Section 16195, Electrical Identification. Identify all switches, control stations, and motor controllers as to their respective equipment.
5. Pilot lights shall be Type Harmony Type 9001 SK as manufactured by Square D or equivalent. Pilot lights shall be of the proper control voltage, LED type, push to test, 30.5 mm, heavy-duty, corrosion-resistant NEMA 4X with legend plates as specified herein, indicated on the Drawings, or otherwise directed by the CMCMUA. Legend plates shall be plastic, black field (background) with white lettering. Pilot light lens colors shall be as follows:

Green	-	"Run", "On", "Open"
Red	-	"Off", "Closed"
Amber	-	"Alarm", "Fail"
White	-	"Control Power On"
6. Pilot lights for all electrical panels shall be of the same type and manufacturer unless otherwise specified herein or indicated on the Drawings.
7. Pilot lights for pump control panels shall be round with custom engraved legend plates for each pilot light.

B. Control and Timing Relays

1. Control Relays (CR) shall be Schneider Electric Type 782 Power Series Relays with full-feature cover and needs to be UL rated components, part number 782XBXM4L-XXX. Mounting base will be din or panel mount with screw terminations part number 70-782D8-1A with plastic hold-down retaining clip part number 16-782PC-1. Relays shall be general purpose tubular pin plug-in type with coil voltage as shown on the Drawings and sealed 10 ampere contacts. All relays shall have three SPDT contacts rated 120/240 VAC, and 28 VDC minimum. Machine tool relays shall be provided when the contact burden exceeds 10 amperes. The relays shall be furnished with an internal pilot light for positive

indication of coil energization. The relays shall be furnished with a manual operator to manually switch the contacts to simulate normal operation. Miniature type or "ice cube" relays shall not be acceptable.

2. Timing Relays (TR) shall be the general purpose plug-in type, Type TR as manufactured by Schneider Electric Corporation, Type 9050 as manufactured by Square D, The Square D Company. Timing relays shall be electronic type with 120 VAC or 24VDC coils unless otherwise specified or indicated on the Drawings. Timers shall be provided with two SPDT timed output contacts. Contact ratings shall be the same as for control relays as specified above and the relays shall use a tubular pin socket.

C. Control Stations

1. Control Stations (CS) shall be as manufactured by Square D Company or equivalent. Control stations shall be furnished and installed complete with PB, SS, and other pilot devices as specified herein or indicated on the Drawings. Stop PB shall be furnished with a lock-out device as specified herein and indicated on the Drawings.
2. CS enclosures shall be cast aluminum with gasketed cover for all indoor dry areas. CS enclosures shall be NEMA 4X stainless steel with gasketed cover for all indoor damp/wet process areas. CS enclosures shall be NEMA 4X stainless steel with gasketed cover for all outdoor applications.
3. CS located in hazardous locations shall be suitable for the Class, Division, and Group to suit the application. The pilot devices shall be the factory sealed type mounted in enclosures as specified above.

D. Miscellaneous

1. Terminal blocks shall be assembled on non-current carrying galvanized steel DIN mounting rails securely bolted to the enclosure or cabinet subpanel. Terminals shall be tubular screw type with pressure plate for wire size #22 - #8 AWG.
2. Power terminal blocks shall be single tier with a minimum rating of 600 volts, 30A. Signal terminal blocks shall be single tier with a minimum rating of 600 volts, 20A. Separate terminal strips shall be provided for each type of power and signal used within each cabinet. There shall be a sufficient quantity of terminals for the termination of all spare field conductors.
3. Terminals shall be marked with a permanent, continuous marking strip. One side of each terminal shall be reserved exclusively for incoming field conductors. Common connections and jumpers required for internal wiring shall not be made on the field side of the terminal. Subject to the approval of the CMCMA, a vendor's pre-engineered and prefabricated wiring termination system may be acceptable.

The terminal blocks shall be as manufactured by Phoenix Contact, Inc., Wieland, Inc., or equivalent.

4. Alarm horns shall be as manufactured by Federal Signal Corporation, Edwards Signaling Company, EST (Edwards Systems Tech), or equivalent. Alarm horns shall be made for surface, flush, or semi-flush mounting on walls, panels, enclosures, or on square outlet boxes. Alarm horn sound output level shall be of 100 dB (nominal) at 10 feet.

E. Condensed Submittal List for PLC Enclosure Equipment

1. The list below contains the products within the Bill Of Material (BOM) from the Drawings for the equipment used in the construction of the PLC Enclosure. Specific part numbers are for reference only as some enclosures are larger or smaller than the example listed below. The list below is for reference and the specific drawings shall be used to determine the specific equipment used in each of the seventeen (17) enclosure to be constructed. Some items listed on the drawing BOM are supplied by the CCMUA and are not included in the table below for submittal.

ITEM	DESCRIPTION	MANUFACTURE	PART #
1	NEMA 12 FREE STANDING DOUBLE DOOR ENCLOSURE, GRAY	HOFFMAN	A726024FSD
2	LED PANEL LIGHT, 24 VDC, IR MOTION SENSOR, MAGNETIC MOUNT	HOFFMAN	LEDD2M35
3	LED LIGHT DC INPUT CONNECTOR/CABLE ASSEMBLY, 78.74"	HOFFMAN	LEDD20C
4	LED LIGHT DC EXTENSION CONNECTOR/CABLE ASSEMBLY, 39.4"	HOFFMAN	LEDD10E
5	DISPLAY PORT/DVI-D SINGLE LINK, 3FT	C2G	54328
6	USB TYPA A TO USB TYPE B 1 METER LONG	C2G	28101
7	APC SMART UPS C BATTERY BACKUP & SURGE PROTECTION 1000VA	APC	SMC1000C
8	STEEL SUB PANEL, WHITE, 60" X 56"	HOFFMAN	A72P60F1
9	M340 PLC 12 SLOT BACKPLANE	MODICON	BMX XBP 1200
10	M340 POWER SUPPLY MODULE 120 VAC	MODICON	BMX CPS 3500
11	M340 PROCESSOR WITH 2048 KB MEMORY	MODICON	BMX P34 2020
12	ETHERNET MODULE, 16 MB RAM, RJ45 10/100	MODICON	BMX NOE 0110
13	64 POINT DIGITAL INPUT MODULE 24 VDC	MODICON	BMX DDI 6402K
14	64 POINT DIGITAL OUTPUT MODULE 24 VDC	MODICON	BMX DDO 6402K
15	4 POINT ANALOG INPUT MODULE	MODICON	BMX AMI 0410
16	4 POINT ANALOG OUTPUT MODULE	MODICON	BMX AMO 0410
17	INTERCONNECTION CABLE 1M	MODICON	BMX FCC 103
18	INTERCONNECTION CABLE 2M	MODICON	BMX FCC 203
19	SCREW TERMINAL STRIP 20PT	MODICON	BMX FTB 2000
20	SLOT PROTECTIVE COVER	MODICON	BMX XEM 010
21	M340 PLC 8 SLOT BACKPLANE	MODICON	BMX XBP 0800
22	BACKPLANE EXPANDER M340	SCHNEIDER ELECTRIC	BMX XBE 1000

23	BACKPLANE EXTENSION CABLE M340, 1.5M	SCHNEIDER ELECTRIC	BMX XBC 015K
24	LINE TERMINATOR FOR RACK END, SET OF TWO	SCHNEIDER ELECTRIC	TSXTLYEX
25	24VDC, 20 POWER SUPPLY	PULS	CPS20.241
26	TYPE 3 SURGE PROTECTION PLUG IN MODULE 120 VAC, 26 AMPS	PHOENIX CONTACT	2839334
27	TYPE 3 SURGE PROTECTION BASE ELEMENT	PHOENIX CONTACT	2839282
28	SINGLE POLE CIRCUIT BREAKER, 20 A, 480 V, UL 489	SQUARE D	M9F42120
29	SINGLE POLE CIRCUIT BREAKER, 15 A, 480 V, UL 489	SQUARE D	M9F42115
30	SINGLE POLE CIRCUIT BREAKER, 5 A, 480 V, UL 489	SQUARE D	M9F42105
31	COMB BUSBAR 12 SINGLE POLE BREAKER	SQUARE D	M9XUP112
32	COMB BUSBAR END CAPS	SQUARE D	M9XCEC10
33	TERMINAL BLOCK RELAY SINGLE POLE 110 V AC/DC	SCHNEIDER ELECTRIC	RSL1PVFU
34	SLIM RELAY 24VDC	SCHNEIDER ELECTRIC	RSL1PVBU
35	TERMINAL BLOCK RELAY JUMPER 20 POINT	SCHNEIDER ELECTRIC	RSLZ2
36	TERMINAL BLOCK RELAY SNAP-IN MARKERS	SCHNEIDER ELECTRIC	RSLZ5
37	LINERGY PASSTHROUGH SINGLE TIER TERMINAL BLOCK 47A WHITE	SCHNEIDER ELECTRIC	NSYTRV42WH
38	LINERGY PASSTHROUGH SINGLE TIER TERMINAL BLOCK 47A GRAY	SCHNEIDER ELECTRIC	NSYTRV42
39	LINERGY PASSTHROUGH SINGLE TIER TERMINAL BLOCK 47A ORANGE	SCHNEIDER ELECTRIC	NSYTRV42AR
40	LINERGY PASSTHROUGH SINGLE TIER TERMINAL BLOCK 47A BLACK	SCHNEIDER ELECTRIC	NSYTRV42BK
41	END COVER FOR SINGLE TIER TERMINAL BLOCKS GRAY	SCHNEIDER ELECTRIC	NSYTRAC22
42	PLUG-IN CENTER JUMPER 10 POSITION GRAY	SCHNEIDER ELECTRIC	NSYTRAL410GR
43	LINERGY PASSTHROUGH SINGLE TIER GROUNDING TERMINAL BLOCK	SCHNEIDER ELECTRIC	NSYTRV42PE
44	FUSE DISC TERMINAL 10 A, LED 12-30V	SCHNEIDER ELECTRIC	NSYTRV42SF6LD
45	LINERGY PASSTHROUGH SINGLE TIER TERMINAL BLOCK 47A BLUE	SCHNEIDER ELECTRIC	NSYTRV42BL
46	END COVER FOR SINGLE TIER TERMINAL BLOCKS BLUE	SCHNEIDER ELECTRIC	NSYTRAC22BL
47	PLUG-IN CENTER JUMPER 10 POSITION BLUE	SCHNEIDER ELECTRIC	NSYTRAL410BL
48	LINERGY PASSTHROUGH TERMINAL BLOCK 30 A DOUBLE DECK BLUE	SCHNEIDER ELECTRIC	NSYTRV44DBL
49	END PLATE FOR DOUBLE DECK TB	SCHNEIDER ELECTRIC	NSYTRACE24

50	LINERGY PASSTHROUGH 3 TIER TERMINAL BLOCK 24A BLUE	SCHNEIDER ELECTRIC	NSYTRV26TBL
51	END PLATE FOR TRIPLE DECK TB	SCHNEIDER ELECTRIC	NSYTRACE26
52	10 POLE PLUG-IN BRIDGE FOR TRIPLE DECK BLUE	SCHNEIDER ELECTRIC	NSYTRAL210BL
53	TERMINAL BLOCK 16 CHANNEL	SCHNEIDER ELECTRIC	ABE7H16C11
54	CONNECTION SUB-BASE ACCESSORY - SNAP-ON TERMINAL BLOCK - 20 SCREW TERMINALS	MODICON	ABE7BV20
55	TERMINAL MARKER CARD	SCHNEIDER ELECTRIC	NSYTRABPV5
56	END CLAMPS 9.55mm WIDE	SCHNEIDER ELECTRIC	NSYTRAABV35
57	DIN RAIL [UNITS = FT]	ALLEN BRADLEY	199-DR1
58	2.26" RAISED DIN RAIL [UNITS = FT]	ALLEN BRADLEY	199-DR6
59	2.26" RAISED 30 DEGREE ANGLED DIN RAIL [UNITS = FT]	ALLEN BRADLEY	199-DR7
60	FAST-ACTING 1/4" X 1 1/4" GLASS TUBE FUSE 2 AMPS	BUSSMANN	AGC-2
61	FAST-ACTING 1/4" X 1 1/4" GLASS TUBE FUSE 5 AMPS	BUSSMANN	AGC-5
62	FAST-ACTING 1/4" X 1 1/4" GLASS TUBE FUSE 8 AMPS	BUSSMANN	AGC-8
63	HANDY BOX 1/2" KO	STEEL CITY	58361-1/2
64	DUPLEX FLUSH RECEPTACLE COVER	STEEL CITY	68-C-7
65	INDUSTRIAL DUPLEX RECEPTACLE 15 A	HUBBELL	5252AB
66	WIRING DUCT, 2" X 4" WHITE [UNIT=FT]	PANDUIT	F2X4WH6
67	WIRING DUCT COVER, 2" WHITE [UNITS=FT]	PANDUIT	C2WH6
68	WIRING DUCT, 3" X 4" WHITE [UNIT=FT]	PANDUIT	F3X4WH6
69	WIRING DUCT COVER, 3" WHITE [UNITS=FT]	PANDUIT	C3WH6
70	GROUND BUS BAR, 24 POINT	GE	TGK24
71	PANEL NAME PLATES, MATTE FINISH BLACK BACKGROUND WITH WHITE LETTERING	GRAVOPLY OR EQUAL	AS REQUIRED
72	CAT 6 ETHERNET CABLE BLUE, 5 FT	BLACK BOX	CAT6PC-005-BL
73	SIDE MOUNT PANEL 60" X 20"	HOFFMAN	A72SMP20

PART 3 -- EXECUTION

3.01 CONFIGURATION OF CONTROLS AND EQUIPMENT

- A. All controls including wiring, control switches, PB, indicating lights, control interlocks and similar devices, shall be provided at the control voltages specified herein or indicated on the Drawings. Each motor starter shall be provided with a control power transformer mounted in the starter unit. Primary wiring to the control power transformer shall be tapped to two (2) poles on the load side of the circuit breaker or fusible switch. Both primary wires shall be fused with 10- ampere, slow-blow fuses. The fuse on the ungrounded secondary side shall be capable of handling 100 percent to 125 percent of the rated control transformer secondary current. Control power transformers shall be provided with volt-

ampere (VA) ratings equal to a minimum of 125 percent of the volt-ampere (VA) load connected to the transformer.

- B. All equipment, cabinets, and devices furnished under the Contract shall be heavy-duty type, designed for continuous industrial service. The system shall contain products of a single manufacturer, insofar as possible, and shall consist of equipment models which are currently in production. All equipment provided shall be of modular construction and shall be capable of field expansion.
- C. All equipment shall be designed to operate on a 60 Hz alternating current power source at a nominal 117 volts, plus or minus 10 percent, except where specifically noted. All regulators and power supplies required for compliance with the above shall be provided.
- D. All switches shall have double-pole, double-throw, contacts rated at a minimum of 600 VA, unless specifically noted otherwise.
- E. Materials and equipment used shall bear a U.L. label wherever such labeling of equipment and materials are available.
- F. Unless otherwise specified or indicated on the Drawings, all equipment shall be designed, furnished, and installed so that in the event of a power interruption, the equipment must be restarted manually after a power failure.
- G. All power terminals shall be insulated and identified.
- H. All instruments shall operate at 10 to 125 degrees F unless otherwise specified.
- I. Internal wiring within all starters, panels, instruments, junction boxes, and similar equipment, shall be brought out to numbered terminal strips for interconnection and field wiring.
- J. All control components shall be mounted in a manner that will permit servicing, adjustment, testing, and removal without disconnecting, moving, or removing any other component. Components mounted on the inside of panels shall be mounted on removable plates and not directly to the enclosure. Mounting shall be rigid and stable unless shock mounting is required otherwise by the manufacturer to protect equipment from vibration. Component's mounting shall be oriented in accordance with the component manufacturer's and industries' standard practices. All internal components shall be identified with suitable plastic or metal engraved tags attached with drive pins adjacent to (not on) each component identifying the component in accordance with the Drawings, Specifications, and supplier's data.
- K. Unless otherwise noted, the Contractor shall provide all interconnecting wiring and conduit for complete control systems. The Contractor shall make all connections to equipment devices, instruments, and all components requiring electrical connection.
- L. The shield on each instrumentation cable shall be continuous from source to destination and shall be grounded as directed by the manufacturer of the instrumentation equipment. In no case shall more than one ground point be employed for each shield. The ground point shall be as specified in Division 17. All analog control functions shall utilize 4-20 mADC control signals, unless otherwise specified. All analog transmission shall take place within shielded twisted cables which are not susceptible to interference or noise.

- M. Lightning/surge protection shall be provided to protect the instrumentation and control system from induced surges propagating along the signal and power supply lines. The protection systems shall be such that the protective level shall not interfere with normal operation, but shall be lower than the instrument surge withstand level, and shall be maintenance free and self-restoring. Equipment shall be housed in a suitable metallic case, properly grounded. Ground wires for all surge protectors shall be connected to a good earth ground and, where practical, each ground wire run individually and insulated from each other. These protectors shall be mounted within the enclosure or in a separate NEMA 4 junction box coupled to the enclosure.
- N. Reference Division 17 - Control and Information Systems for additional information regarding lightning/surge protection requirements.

3.02 FIELD TESTS

- A. The Contractor shall conduct field tests prior to operation of the equipment. The CMCMUA shall witness all field testing. Field testing shall be conducted at a time approved by the CMCMUA. Field tests shall be conducted for all hardware components and shall include a functional check of all items. Field tests shall include a functional check of all instruments and control equipment. All equipment shall be connected and fully operational for field testing. Field tests shall demonstrate that the controls perform according to the Contract requirements and that all equipment, valves, switches, controls, alarms, interlocks, indicating lights, and similar equipment function properly. Based on the results of field tests, the Contractor shall make any required corrections to equipment and controls and shall make any adjustments required to the control logic and control settings to achieve the specified operation or operation otherwise directed by the CMCMUA. Field tests shall be conducted for the full range of operating modes and conditions specified and as directed by the CMCMUA. The Contractor shall make modifications and adjustments to the controls as directed by the CMCMUA for optimizing operation of the overall system. All costs in connection with field tests of equipment provided under the Contract, shall be borne by the Contractor. The Contractor shall be fully responsible for the proper operation of all motor starters and controls during the tests.

(END OF SECTION)