APPENDIX B

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DIVISION 16

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PART 1 – GENERAL

1.01 WORK INCLUDED

A. The WORK included under this specification consist of furnishing all equipment, materials, start-up services, specialty tools, and other equipment necessary for the electrical and control equipment fabrication, delivery, and testing as specified herein.

B. The intent of the electrical specifications is to provide enough information to the manufacturer to illustrate the electrical equipment standards and requirements for which the power and control system are to be fabricated. All field installation (except the required manufacturer's checking, start-up, and testing) will be done by others.

1.02 REFERENCE STANDARDS

A. All equipment, materials, and methods of design and manufacture are to comply with the National Electrical Code, the basic Electrical Regulations of the State where the equipment is to be installed, the Occupational Safety and Health Act (OSHA), and the requirements of all other applicable codes. Codes and standards of the following organizations may be referred to in this section and shall be considered as the minimum acceptable. A reference herein to any portion of the standard or code is not to be considered as negating any other portion of the standard or code.

   ANSI  American National Standards Institute, Inc.
   IEEE Institute of Electrical & Electronic Engineers
   ASTM American Society for Testing & Materials
   UL Underwriters Laboratories, Inc.
   NEMA National Electric Manufacturers Association
   IPECA Insulated Power and Cable Engineers Institute
   NEC National Electric Code
   ISA Instrument Society of America

B. All electrical equipment shall be listed by and shall bear the label of Underwriters' Laboratories, Inc. (UL) or an independent testing laboratory acceptable to the local code enforcement agency having jurisdiction.

C. Where these specifications require a higher degree of workmanship or quality of material than the above codes and standards imply, then these specifications will prevail.
1.03 EQUIPMENT SUPPLIER SUBMITTALS

A. Make all submittals in accordance with Section 01300 – EQUIPMENT SUPPLIER SUBMITTALS.

B. Within 15 days after the contract award, submit material lists for this section of the work. Lists will include manufacturer and brand name of each class of material.

C. Submit complete shop drawings for review prior to manufacture or assembly of the equipment.

1. Drawings will show:

   a. Elevations
      Layout and Construction details

   b. Bill of Material
      Nameplates
      Temperature limitations
      Voltage requirement, phase, and current, as applicable
      Grounding requirements (if applicable)
      Catalog cut sheets or brochures for mass produced, non-custom manufactured material.

D. Package drive diagrams are to be of the elementary type and show terminal identifications and associated field connections for each drive.

E. Provide Operation and Technical Manuals in accordance with Section 01300 – EQUIPMENT SUPPLIER SUBMITTALS.

1.04 QUALITY ASSURANCE

A. All equipment furnished under this section will be guaranteed for a minimum period of one (1) year from date of accepted installation against defective materials, design, and workmanship in accordance with the provisions of the General Conditions.

B. Tests

1. The EQUIPMENT SUPPLIER shall be responsible for all factory tests required by specifications in Division 16 and by the ENGINEER or other authorities having jurisdiction. The EQUIPMENT SUPPLIER shall furnish necessary testing equipment and replacement parts resulting from damaged/failed equipment from testing.

2. Where test reports are indicated, proof of design tests reports for mass-produced equipment shall be submitted with the Shop Drawings, and factory performance test reports for custom-manufactured equipment shall be submitted and be approved prior to shipment. Test reports shall be submitted for review prior to Submittal completion.

3. Equipment or material that fails a test shall be removed and replaced. All tests which do not pass shall be repeated after identifying and correcting the problems. Any corrections to equipment or materials that are furnished with a factory warranty shall
be corrected per the recommendations of the manufacturer and in a manner which does not violate the terms of the warranty.

1.05 AREA DESIGNATIONS

A. Electrical equipment and components location shall comply with requirements listed in the table below:

<table>
<thead>
<tr>
<th>Area</th>
<th>NEMA ENCLOSURE CLASSIFICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Below grade vaults, manholes, etc.</td>
<td></td>
</tr>
<tr>
<td>Outdoors, non-hazardous, non corrosive locations</td>
<td>X</td>
</tr>
<tr>
<td>Outdoors, non-hazardous, corrosive locations</td>
<td>X</td>
</tr>
<tr>
<td>Outdoors, hazardous, non-corrosive locations</td>
<td></td>
</tr>
<tr>
<td>Outdoors, hazardous &amp; corrosive locations</td>
<td></td>
</tr>
<tr>
<td>Building Interior, non-hazardous, non corrosive locations</td>
<td></td>
</tr>
<tr>
<td>Building Interior, non-hazardous, corrosive locations</td>
<td></td>
</tr>
<tr>
<td>Building Interior, hazardous, non corrosive locations</td>
<td></td>
</tr>
<tr>
<td>Building Interior, hazardous &amp; corrosive locations</td>
<td></td>
</tr>
</tbody>
</table>

B. Electrical WORK not included in the table above shall be NEMA 4X, unless applicable code requires otherwise.

C. Installation in hazardous locations shall conform strictly to the requirements of the Class, Group and Division indicated or required by applicable codes.
PART 2 – PRODUCTS

2.01 GENERAL

A. All equipment and material is to be new, free from defects, of current manufacture, and listed by Underwriters Laboratories, Inc., (UL) where UL requirements apply. All materials are to be products of reputable and experienced manufacturers. Similar items in the project are to be of the same manufacturer. Use only equipment and materials of industrial quality and durability, and capable of long, reliable, trouble free service.

2.02 MOUNTING HARDWARE

A. Miscellaneous Hardware

1. All nuts and bolts shall be stainless steel.

2. Anchors for attaching equipment to metal skids shall be stainless steel.

2.03 ELECTRICAL IDENTIFICATION

A. Nameplates: Nameplates shall be fabricated from white-letter, black face laminated plastic engraving stock, Formica Type ES-1, or equal. Each shall be fastened securely, using fasteners of brass, cadmium plated steel, or stainless steel, screwed into inserts or tapped holes as required. Engraved characters shall be block style with no characters small than 1/8-inch top to bottom.

B. Conductor and Equipment Identification: Conductor and equipment identification devices shall be either imprinted plastic-coated cloth marking devices such as manufactured by Brady, Thomas & Betts, or equal, or shall be heat-shrink plastic tubing, imprinted split-sleeve markers cemented in place, or equal.

2.04 SIGNAGE AND MARKINGS

A. Provide danger, caution, and warning signs and equipment identification markings in accordance with applicable federal and state OSHA and NEC requirements.

2.05 TERMINAL BLOCKS

A. Terminal Blocks where required shall be screw terminal, heavy duty, rated at 20 amperes minimum, 600 volt AC. Terminals shall be provided with integral marking strips which shall be permanently identified with the connecting wire numbers as shown on the drawings. Each terminal block shall be uniquely identified.

PART 3 – EXECUTION

3.01 INSTALLATION

A. Documents: The EQUIPMENT SUPPLIER shall provide detailed installation drawing depicting necessary wiring, interlocks, etc. for use by a subsequent installation CONTRACTOR.
3.02 EQUIPMENT IDENTIFICATION

A. Equipment and devices shall be identified as follows:

1. Nameplates shall be provided for pumps and motors, control and instruments. In addition to nameplates, control devices shall be equipped with standard collar-type legend plates.

2. Control devices within enclosures shall be identified as indicated. Identification shall be similar to the subparagraph above.

3. Equipment names and tag numbers, which indicate on the Drawings, shall be utilized on nameplates.

4. Terminal point on terminal blocks shall be labeled by identifiers attached to the terminal strip. Identifiers shall be pre-printed by the terminal manufacturer custom printed markers, hand lettered markers shall be acceptable.

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SECTION 16100 – BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.01 DESCRIPTION

Requirements specified in Conditions of the Contract and Section 16050 form a part of this section. This Section outlines the requirements for the basic electrical materials and methods for the electrical work, and forms a part of all other Sections of Division 16 unless otherwise specified.

A. Related Work Included in Other Divisions or Sections (Related Work not Included in This Section).

1. Instrumentation, Division 13.
2. Induction Motors, Section 16150.
3. Variable Frequency Drive Controllers, Section 16483
4. Conductors and cables, Section 16120.
5. Electrical Equipment Testing, Section 16960.

1.02 SUBMITTALS

Submit for the CITY’s approval material lists, shop drawings, factory test reports and technical data to the extent required in this Section and Section 16050.

1.03 WIRING

Wiring for furnished equipment shall include the following:

A. Wiring for Furnished Equipment. The wiring diagram from components to a skid mounted terminal box (if any) shall be provided.

PART 2 - PRODUCTS

2.01 GENERAL

Provide basic materials and all wiring installations as indicated, specified and required.

2.02 METAL CONDUITS (IF APPLICABLE)

A. Metal conduits shall be steel, hot-dipped galvanized (including threads) and equipped with couplings and thread protector caps. The surfaces and threads shall be corrosion-resistant coated. Conduits shall be in ten foot lengths and manufactured in accordance with U.L. 6 by Triangle, Pittsburgh, V.A.W., and Wheatland, Allied or equal. Conduits shall be a minimum size of 3/4 inch.

B. PVC Coated Conduit shall have a polyvinyl chloride coating bonded to the outer surface of rigid steel conduit and couplings. The plastic coating for all PVC coated
conduit shall have an average thickness of 0.040 inches. The bonding of the PVC coating to the conduit shall be stronger than the tensile strength of the PVC coating. The polyvinyl chloride coating shall be bonded to the galvanized surface of rigid steel conduit by Youngstown, Kor-Kap, Occidental Coating, Robroy or equal.

2.03 FLEXIBLE CONDUIT (IF APPLICABLE)

A. Liquid-tight Flexible Conduit shall have an interlocked, flexible, galvanized steel core, permanently bonded UV resistant exterior gray polyvinyl chloride jacket and shall be UL listed.

B. Conduits, 1-1/4 inch and smaller shall have an internal copper bonding conductor wound spirally in the space between each convolution.

C. Manufacturers of liquid-tight flexible conduit shall be Anaconda (by Anamet, Inc.), Type UA, Electri-Flex Type LA, Universal or equal.

2.04 CAST METAL BOXES AND FITTINGS (IF APPLICABLE)

Cast boxes and fittings shall be finished as specified in Section 16050. The outlet bodies, boxes, fittings, covers and supports shall be cast iron alloy with threaded hubs. The materials shall be manufactured by Crouse-Hinds, Appleton, Pyle-National, Efcor or equal.

A. Covers and Gaskets shall be provided for all conduit outlet bodies, boxes and fittings. The covers shall be cast iron alloy and equipped with neoprene gaskets. Explosion-proof boxes shall have externally threaded surface covers.

B. Seal Fittings shall be Crouse-Hinds Type EYS or equal. Ceramic or other non-asbestos fiber materials and sealing compound, UL listed to match the fitting, shall be provided for completing the seal.

C. PVC Coated Fittings shall have the same polyvinyl chloride coating that is on the conduit to which they shall be connected. The PVC coating shall have an average thickness of 0.040 inches and the bonding shall be stronger than the tensile strength of the PVC coating. The PVC coating shall be bonded to the surfaces of cast outlet bodies, boxes, fittings, supports, etc. by Occidental Coating, Kor-Kap, Robroy, Youngstown, or equal.

D. Plastic Fittings shall be solvent weld type and shall be compatible with the conduit to which they shall be connected.

E. Expansion/Deflection Fittings shall consist of cast metal conduit hubs securely attached to a flexible outer neoprene jacket. A flexible copper grounding strap shall be provided inside the fitting and connected to the two hubs. The linear expansion or contraction shall be a movement up to 3/4 inch. The linear misalignment shall be a movement up to 3/4 inch. The angular misalignment shall be a movement up to 30 degrees. The expansion/deflection fittings shall provide flexible and watertight conduit joints.

F. Thread Lubricant shall inhibit corrosion and maintain grounding continuity, and shall be Crouse-Hinds STL, Thomas and Betts "Koper-Shield" or UL listed equal.
G. Couplings and Elbows. For rigid steel conduits, the couplings and elbows shall be steel, hot dipped galvanized, threaded and one-piece. For plastic conduits, couplings and elbows shall have plain ends for tight weld fits, which form watertight joints. For joining plastic and rigid steel conduit systems, couplings shall have a plain end and a threaded end.

2.05 STEEL BOXES AND FITTINGS (IF APPLICABLE)

A. Pull Boxes. Boxes 24 inches square and smaller shall have gasketed screw type covers. Larger boxes shall have bi-parting gasketed hinged doors with latch mechanisms, handles and cylinder locks complete. Provide two keys for each lock. Pull boxes shall be painted as specified in Section 16050. The pull boxes shall be Hoffman, Boss, Circle A-W or equal.

B. Outlet Boxes and Fittings for connections to concealed steel electrical metallic tubing (EMT) shall be galvanized, pressed steel, one piece, knock-out type. Box extensions, plaster rings and covers shall fit. See Article 3.03. of this Section for required sizes. Outlet boxes and fittings shall be Appleton, Bowers, Steel City or equal.

2.06 WATER AND GAS SEAL FITTINGS (IF APPLICABLE)

A. Water and gas seal fittings shall consist of a thick, synthetic rubber, sealing ring secured between two metal plates by socket head screws. When the conduit water and gas seal fitting is in place and the screws are tightened, the synthetic rubber shall become compressed between the metal plates and be forced against the conduit inside wall and also against the conductor insulation to form a watertight seal inside the conduit. The synthetic rubber shall resist aging, ozone, sunlight, water, chemicals and extreme temperature variations. The water and gas seal fittings shall be O-Z/Gedney Type CSB or equal.

B. Water and gas wall and floor seals shall consist of a synthetic rubber sealing ring between two pressure rings or a series of synthetic rubber links between pressure plates held together with corrosion resistant bolts, nuts and washers. When the bolts are tightened, the synthetic rubber expands to provide a watertight seal between the outer surface of the entering conduit, and the inner surface of the wall or floor penetration. The synthetic rubber shall resist aging, ozone, sunlight, water, chemicals and extreme temperature variations. The seals shall be Thunderline "Link-Seal", O-Z/Gedney Type CSM, and FSK, WSK or equal.

2.07 CONDUIT FITTINGS

Conduit fittings shall be hot dipped galvanized steel and cast iron as required.

A. Liquid-tight Conduit Fittings shall be Types LT, ST, CT as manufactured by Crouse-Hinds, Appleton, Pyle-National or equal. Fittings 1-1/2 inch and larger shall have provision for a separate equipment ground conductor.

B. Unions shall be type UNY or UNF. Running threads are not acceptable. Unions shall be Appleton, Crouse-Hinds, Pyle-National or equal.

C. Bushing reducers shall be Appleton, Thomas and Betts, Efcor or equal.
D. Conduit Enlargers shall be Appleton, Thomas and Betts, Efcor or equal.

E. Locknuts shall have notches all around for tightening with a screwdriver. Locknuts shall be Appleton, O-Z, Thomas and Betts or equal.

F. Metallic Insulated Bushings shall have ground terminals and smooth and well rounded surfaces to protect the conductor insulation. The conduit threads shall be deep, clean and easily attached to the conduits. The bushings shall be O-Z, Efcor, Thomas and Betts or equal.

G. Plugs shall be the recessed type and Appleton, Crouse-Hinds or equal.

H. Interchangeable Hubs shall have an insulated throat, sealing ring and vibration-proof nut. Machined serrations on hub and nut shall bite into the metal enclosure assuring an equipment ground. The hubs shall be Myers "Scru-Tite", Efcor "Space-Saver" or equal.

I. Conduit seals shall be Crouse-Hinds type EYSX expanded fill sealing fitting or equal.

2.08 CONDUCTORS AND CABLES (IF APPLICABLE)

Conductors and cables shall be new, single conductor, copper, not smaller than #12 AWG (except control wires when installed inside conduit which may be #14 AWG) unless otherwise indicated, and as shown on the drawings. Control wires at panel and cabinet can be #16, machine tool grade type MTW, UL approved and rated for 90 degree C at dry location. All multi-conductor cables shall be approved for cable tray installation.

A. Conductors 250 kcmil and larger shall be stranded, 600 volts, flame retardant, ethylene propylene rubber insulation, UL labeled, Type RHW, without outer covering. Insulation other than ethylene propylene rubber shall not be used. Conductors shall be Rome FR-EPR, Okonite-FMR, Houston Wire and Cable FREP or equal.

B. Conductors smaller than 250 kcmil shall be stranded (except #10 and #12 for lighting and receptacle circuits which shall be solid), 600 volt and Type THWN or THHN. Conductors shall be Rome, Carol Cable, Techbestos, Triangle, Atlas, Northern or equal. Sizes #10 and smaller shall have colored insulation where indicated.

C. Ground and Neutral Conductors.

1. Insulated ground and neutral conductors shall be the same type as the phase conductors, except for circuits above 600 volts which shall be Type THWN.

2. Bare ground conductors shall be copper, soft drawn, annealed, concentric lay, stranded conforming to ASTM Specifications B3 and B8.

D. Fixture Wires shall be rated 90° centigrade, #16 AWG stranded, thermoplastic insulated with an outer jacket. The wire shall be Type TFFN and manufactured by Brand-Rex, Carol Cable or equal.

E. Instrumentation Signal Cables shall be single twisted pair or multi twisted pairs of stranded, copper cables with 600 volt, 15 mil polyvinyl chloride insulation with 4 MIL nylon jacket over each conductor, overall aluminum-mylar tape shield, overall tinned
copper drain wire and 45 mil minimum polyvinyl chloride jacket overall, 90° centigrade dry/75° centigrade wet rating. Twisted pair cables that are required to be shielded, shall have aluminum-mylar tape shields and tinned copper drain wires over individual twisted pairs of cable. Single twisted pair cables shall be #16 AWG minimum. Cables shall be Okonite "Okoseal-N-type P-OS, type TC", Dekoron type TC or equal.

F. Wire Lubricant shall be Burndy "Silkon", Holub "Hi- Green", Ideal "Yellow 77" or equal.

G. Identifications on the conductors and cables shall be continuous and include the type, voltage, size and name of the manufacturer.

2.09 WIRE CONNECTORS (IF APPLICABLE)

Connectors shall be provided for splices and terminal connections of all conductors and cables. The connector shall fit the conductor to which it shall be connected, and the assembly shall have joint contact surfaces not less than 50 percent.

A. Compression Connectors shall be copper lugs for terminal connections, and two-way copper sleeves and taps for splice connections. A crimping tool shall be provided to make tight and neat compression connections. The connectors and crimping tool shall be Anderson-Square D, Thomas and Betts, Buchanan or equal.

B. Tapered Spring Connectors shall have live springs attached to inner steel housings and enclosed with plastic insulators, and shall be Buchanan B-Cap, 3-M, Scotchlok Type Y, R, G, B, Ideal Wire-Nut or equal.

C. Connectors in all manholes, handholes and flush with grade pull boxes shall be watertight. Connector splice kits for the wire range size for which they apply shall be 3M Type DB-6 and DBR-6, Buchanan B-cap Twist and Seal, or equal.

D. Electrical Tape shall be plastic, 0.007 inches thick, and resistant to abrasion, alkalies, acids, corrosion, moisture, low and high temperatures. The tape shall be Scotch No. 33 Plus, Plymouth Premium Black No. 4453 or equal.

E. Wire Markers. The individual conductor wire markers shall be adhesive and manufactured by Thomas and Betts, Brady, Scotch 3M or equal. The wire marker to identify groups of conductors shall be nylon cable tie markers as manufactured by Thomas and Betts, Panduit or equal. The marker pads on the cable tie markers shall be large enough to show the motor or device numbers using minimum 3/16 inch high numbers and letters. Manufacturer shall provide permanent marking pens.

2.10 PANELBOARDS (IF APPLICABLE)

Panelboards shall be factory assembled, metal enclosed, dead front and equipped with bus, time switches, contactors, terminals and thermal-magnetic molded case circuit breakers as shown on the drawings.

A. Circuit Breakers shall be molded case, quick-make, quick-break, single and multipole, bolted type, and arranged as shown on the drawings. Each circuit breaker shall have clear indications for "ON", "OFF" and "TRIP" positions. The minimum interrupting capacity shall be 14,000 symmetrical amperes at 240 volts (65,000 symmetrical
amperes at 480 volts). As indicated, provide devices to lock the branch circuit breaker in the "ON" and "OFF" positions. Ground fault protection, 5 milliampere sensitivity, shall be provided for the indicated branch circuits, which shall be an integral part of the regular branch breaker. A circuit breaker with integral ground fault circuit interruption shall require no more panelboard branch circuit space than the regular circuit breaker. Branch circuits that have exterior convenience outlets, toilet convenience outlets, laboratory convenience outlets and as indicated shall be equipped with ground fault protection.

B. Copper Bus shall be provided for panelboard. Bus shall be provided for the complete length of the panelboard branch circuit area including circuits indicated as spaces. Bus bars shall be drilled and tapped for the indicated spaces for installation of future circuit breakers.

C. Single Phase Panelboard, three wires, shall be bussed so that any two adjacent single-pole breakers shall be connected to opposite polarities. A single handle two-pole circuit breaker can be installed in any location, and in place of two adjacent single pole breakers.

D. Three Phase Panelboard, four wires, shall be bussed so that any three adjacent single-pole breakers shall be connected to different phases. A single handle two-pole breaker or three-pole breaker can be installed in any location, and in the same space of two or three adjacent single pole breakers.

E. Terminals and connectors shall be provided for all feeder, branch, neutral and ground conductors shown on the drawings.

F. Circuit Numbers shall start at the top of the panelboard. Odd numbers shall be assigned in sequence on the left side, and even numbers shall be in sequence on the right side of the panelboard.

G. The Cabinet shall enclose the bus and breaker assembly, and shall be steel fabricated and coated with corrosion-resistant finish as specified in Section 16050. The front of the panelboard shall include a trim, hinged door, flush cylinder lock with catch. The lock shall be furnished with two keys, and all locks shall be keyed alike. Fronts shall not be removable when the door is in the locked position.

H. Time Switches shall be provided as indicated and specified in Section 16900.

I. Contactors shall be provided as indicated and specified in Section 16900.

J. Metal Circuit Directory frame and card with clear plastic covering shall be provided on the inside of the door. The directory card shall provide a space at least 1/4-inch high and 3 inches long for each branch circuit. The card shall be completely typed to identify each connected circuit, spare and space.

K. Manufacturers for three phase, 480Y/277 volt panelboard shall be Square D Type NHEB, Cutler-Hammer POW-R-LINE 2, General Electric Type AE or equal. The single phase 120/240 volt and three phase 208Y/120 volt panelboard shall be Square D Type NQOD, Cutler-Hammer POW-R-LINE 1, General Electric Type AQ or equal.
2.11 SUPPORTS

A. Channels shall be steel, cold rolled and PVC coated. One side of the channel shall have a continuous slot. On both sides of the slot, the edges turn inward and form a guide for the spring nuts. The fittings shall be fabricated from steel and attached to the channel with bolts and spring nuts. The channel, fittings and hardware shall be hot-dipped galvanized, and then PVC coated and manufactured by Unistrut, Power-Strut, Kindorf or equal.

B. One-Hole Clamps shall be malleable iron, galvanized for steel conduits and equipped with clamp-backs. The clamps shall be Efcor, Thomas and Betts, Appleton or equal.

C. Beam Clamps shall be malleable iron, galvanized, right angle and parallel types. The clamps shall be manufactured by Efcor, Thomas and Betts, Appleton or equal.

D. Spacers, provided to support underground conduits in concrete encasements, shall be plastic. The spacers shall be Carlon, Johns-Manville, Underground Products or equal.

E. Steel Anchors shall be sleeve and stud types for securing equipment to concrete foundations, floors and walls. The anchors shall be Phillips "Red Head", Diamond or equal.

F. Toggle Bolts shall be steel, spring wing type for securing equipment to hollow walls and ceilings. Toggle bolts shall be Phillips "Red-Head", Diamond or equal.

G. Stanchions shall be structural steel as shown on the drawings, shop fabricated, coated with a rust inhibiting primer per requirements of "Painting and Protective Coatings" Section of the Specifications.

H. Conduit Hangers shall be heavy gauge formed steel, galvanized and then PVC coated and equipped with carriage bolts, 1/4-inch rods and nuts. The hangers shall be Efcor, Kindorf, Appleton or equal.

I. U-Bolts shall be heavy gauge steel, galvanized and equipped with two hexagon steel nuts. The U-bolts shall be Efcor, Kindorf or equal.

J. Fixture Hangers shall be cast iron alloy, cushion type, equipped with cover, screw terminal blocks, and permits the pendant to swing 20 degrees from perpendicular in any direction. Hangers shall be Crouse-Hinds Type ALT, Appleton Type ALT, Pyle-National Type A-2152M or equal.

K. Guardrail clamps, guardrail and conduit in a location should be of the same metal. Where dissimilar metals shall be joined together, the clamps shall be PVC coated and attached with stainless steel hardware.

L. Hardware for corrosive areas shall be 316 stainless steel.

2.12 NAMEPLATES

A. The Nameplates shall be engraved, laminated black plastic with minimum 1/4 inch high letters showing through from the white core, NEMA ES-1, 3-ply (Black-White-Black),
1/16-inch thick, beveled and satin finished. Nameplate inscriptions shall include the identifications for the equipment and loads and shall identify the controls on control equipment as shown on the Drawings. Nameplates shall be provided on receptacle plates with 1/8 inch high letters.

2.13 TAGS

Tags shall be 1/16 inch thick stainless steel and shall have embossed (raised) lettering. Lettering shall be a minimum of 3/8 inch high. Provide a 1/8 inch hole at each end for mounting or wire attachment. All corners shall be rounded and edges ground smooth.

PART 3 – EXECUTION

3.01 GENERAL

Provide the wiring installations and equipment installations, including connections and interconnections as indicated, specified and required in a neat and workmanlike manner. Assure proper fits for all equipment and materials in the spaces shown on the drawings.

3.02 RACEWAYS

Provide all conduit installations, including the outlet bodies, boxes, gaskets, covers, fittings and supports to complete the raceway systems as shown on the drawings and as required. Conduits shall be a minimum size of 3/4 inch. All exposed conduits shall be PVC coated. Install ground conductors in all conduits. This paragraph applies if electrical equipment and components mounted on skids are pre-wired in the factory to a common pull-box or marshalling box.

A. No run of conduit, between device, equipment, box or fitting and another device, equipment, box or fitting, shall contain more than the equivalent of three 90 degree bends (270 degrees total), including offset bends located immediately at the device, equipment, box or fitting.

B. Couplings and Elbows shall be of the same type as the conduit to which they shall be connected, except where rigid steel bends and risers are connected to non-metallic conduits where conduits rise above grade.

C. Flexible Conduits. Flexible conduits shall be liquid-tight with fittings for short tight connections (30 inches maximum) to equipment, except in Class 1, Division 1 areas. A separate ground conductor shall be installed in flexible conduit that does not have the internal copper bonding conductor included by the manufacturer.

D. Threads. All steel conduit threads shall be coated with a conductive, corrosion resisting lubricant, and the connections shall be made watertight. The lubricant shall maintain the grounding continuity.

E. Conduit Connections. Where conduits are connected to couplings, fittings, boxes, etc., a minimum of 5 threads shall be engaged so that the system is rigid and sturdy. Also, the tapered portion of the threads shall be sufficiently engaged to provide electrical continuity. The use of lock-nuts, or other gimmicks with threaded fittings to add rigidity, is not acceptable. Unions shall be provided, as required, for conduit
connections to threaded outlet bodies, boxes and equipment, and for connecting two steel conduits together. Conduit enlargers shall be provided for connecting two conduits of different sizes together.

F. Water and gas seal fittings shall be provided on all conduits that enter or leave corrosive areas. The seal fitting shall prevent corrosive gases from passing from a corrosive area to a non-corrosive area through the conduit system. Ceramic or other non-asbestos fiber material and sealing compound shall be placed in the fitting to complete the seal.

G. Water and gas seal fittings shall be installed on the ends of exterior conduits that terminate at indoor equipment. The fittings shall provide a water and gas tight seal between the wires and cables and the inside of the conduit.

H. Water seal fittings shall be installed to completely water seal the areas around conduits that pass through concrete floors and outside walls, unless concrete is placed after conduit is installed.

I. Tool Marks. Conduits and fittings that have tool marks shall be smoothed and finished with paint that matches the original finish.

3.03 BOXES AND FITTINGS

Conduit outlet bodies, boxes, fittings, gaskets, covers and supports for lighting outlets, lighting switches, receptacles, control stations, alarm, switch and thermostat outlets, etc. in exposed conduit installations, shall be installed as indicated, specified and required, and shall be of sufficient size to provide free space for all conductors that shall be enclosed.

A. Cast Iron. Cast iron outlet bodies, boxes, gasketed covers and fittings shall be connected to expose galvanized rigid steel conduits.

B. PVC Coated. Outlet bodies, boxes, gasketed covers and fittings shall be PVC coated and connected to PVC coated steel conduits.

C. Sheet Steel. Sheet steel boxes shall be of sufficient size to accommodate the connected conduits and enclosed conductors and provided with close-fit holes for steel conduit connections. Weatherproof boxes shall be provided with interchangeable conduit hubs for steel conduit connections as indicated.

D. Interchangeable Hubs. The hubs shall be installed in steel enclosures for rigid steel conduit connections. Cut a close fitting hole in the sheet steel enclosure and place the interchangeable hub in the opening. Connect the hub on the conduit and make a tight connection to the enclosure.

3.04 CONDUCTORS, CABLES, CONNECTIONS AND WIRE MARKERS

Install all the conductors, cables and connections for the wiring as indicated, specified and required. Recommended pulling tensions shall not be exceeded. Provide separate neutral conductors as required. Ground conductors shall be insulated wire unless noted otherwise on the Drawings.
A. Conductors. Conductors shall be completely installed and connected. Apply wire lubricant to ease the pulling of conductors in conduits. Splice and terminal connections shall be made tight with spring and compression connectors. The connectors shall be crimped with a tool that provides uniform and tight connections. Connectors shall be sized as outlined in paragraph on Wire Connectors in this Section. Include all the required wiring interconnections. When routing conductors and cables through pull boxes, the longest (not shortest) route from entrance to exit shall be used.

B. Connections.

1. Low Voltage Connectors. Connectors for conductors No. 8 AWG and larger shall be compression type. Use the provided crimping tool to make tight and neat compression connections. Connectors for conductors No. 10 AWG and smaller shall be tapered spring type.

2. Conductor and cable splices shall be located only in pull-boxes, junction boxes, handholes and manholes.

C. Insulate. All connections shall be insulated as required with tight wraps of plastic tape.

D. Furnished Equipment. Provide wiring installations as shown on the drawings, and specified in other Sections of the Specifications for furnished equipment.

3.05 SUPPORTS

Install the required structural channels, brackets, stanchions, U-bolts, clamps, anchors, hangers, fittings and other hardware to securely attach and support all the equipment, materials and conduits, as indicated, specified and required. Supports shall be PVC coated in corrosive areas.

A. Painting. Brackets, stanchions and other unfinished steel supports shall be painted per requirements of Section 09900 (NOT APPLICABLE).

3.06 NAMEPLATES

Nameplates shall be provided as indicated to identify equipment, and the positions and circuits within the equipment. Also, individually enclosed equipment shall be provided nameplates as indicated. Plastic nameplates shall be positioned and lined-up to provide a neat appearance, and shall be attached to the cleaned metal surfaces of enclosures with stainless steel screws.

A. Plastic Nameplates. Nameplates shall be provided on primary interrupters, switchgears, substations, switchboards, service equipment, motor controllers, motor control centers, panelboards, and individually enclosed circuit breakers, disconnect switches, magnetic starters, manual starters, relays and control stations unless otherwise indicated. Provide lighting switch nameplates as indicated on the drawings.

B. Nameplates shall be attached to the object, or adjacent to the object, with self tapping screws. Adhesive materials shall not be used for attachment. Objects such as explosion proof enclosures, that would have their UL listing nullified by drilling for mounting screws shall have their nameplate mounted on an adjacent wall or plate provided by the Constructor.
3.07 CHECKING, ADJUSTING AND TESTING

Provide the required labor and equipment, and all checking, adjusting and testing in the factory.

A. Check. All wire terminals shall be checked to assure tight connections.

B. Tests.

1. Tests shall be per Section 16960.

2. For items not included in Section 16960, tests shall be performed per NETA and IEEE standards, to detect wrong connections, short circuits, continuity and ground. Tests shall be made with a hand crank test instrument (megger) on all transformer windings, motor windings and all cables and conductors.

NOTE: WARNING. Do not make insulation tests on any conductors either signal or power that are connected to semi-conductor type equipment. Disconnect the conductors from the equipment before insulation testing; severe damage may result from megger-type instruments. Power feeders and branch conductors shall be tested phase to phase and phase to ground. Phase to ground tests on shielded cable shall mean "conductor to shield". After insulation resistance tests have been performed, high voltage and medium voltage shielded cables shall be "hi-Pot" tested in accordance with the current ICEA Standards and the manufacturer's recommendation. Voltage shall be applied and removed in a slow, even manner, and the conductors shall be grounded for at least one minute after the voltage is removed to insure that no charge remains. Test voltage and application time for the various cables and conductors shall be submitted to the CITY. Correct any defects in the wiring systems.

C. Equipment Tests. Perform equipment tests as indicated and directed at the factory.

D. Test Data. Test data for equipment shall be submitted to the CITY.

– END OF SECTION –
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SECTION 16120 – CONDUCTORS AND CABLES

PART 1 – GENERAL

1.01 WORK INCLUDED

A. This Section includes building wires and cables and associated connectors, splices, and terminations for wiring systems rated 600 V and less. This specification is applicable for all factory wired and skid mounted equipment and electrical components.

1.02 REFERENCE STANDARDS

A. This section references the latest revisions of the following documents. They are a part of this section as specified and modified. In case of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

ASTM B 3 Soft or Annealed Copper Wire
ASTM B 8 Concentric-Lay-Stranded Copper Conductors, Hard, Medium Hard or Soft
ASTM B 33 Tinned soft or Annealed Copper Wire for Electrical Purposes

PART 2 – PRODUCTS

2.01 GENERAL

A. Cables shall be identified on the overall jacket as to the manufacturer's name, cable size, number of conductors, type of insulation, type of jacket, cable type, and voltage rating.

2.02 600 - VOLT CABLE

A. Wire: All conductors shall be copper. No aluminum shall be used. Sizes No. 12 and 14 American Wire Gauge (AWG) shall be solid conductors; wires No. 10 AWG and larger shall be stranded. All control wire installed inside conduit shall be stranded, No. 14 AWG minimum. Provide conductors with Type Thermoplastic High Heat-resistant Nylon-coated/ Thermoplastic High Water-resistant Nylon-coated (THHN/THWN) insulation, unless installation conditions or applicable codes requires otherwise.

B. Identification: All 600-V wiring used in power circuits shall be color coded in accordance with the following table. Wire sizes No.6 AWG and smaller shall be factory colored; wire sizes No.4 AWG and larger shall be black with colored vinyl tape applied at all splices and terminations.
### Use

<table>
<thead>
<tr>
<th>Use</th>
<th>Cable</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Three-phase, 480V/277V power and lighting</td>
<td>Phase A Phase B Phase C Ground Neutral</td>
<td>Brown Orange Yellow Green Gray or White with distinctive stripe</td>
</tr>
<tr>
<td>Three-phase, 208Y/120V</td>
<td>Phase A Phase B Phase C Ground Neutral</td>
<td>Black Red Blue Green White</td>
</tr>
<tr>
<td>Single-phase, 3 wire 120/240V power</td>
<td>Phase A Phase B Ground Neutral</td>
<td>Black Red Green White</td>
</tr>
</tbody>
</table>

C. Sources: The Okonite company. Anaconda-Ericsson, or approved equal.

#### 2.03 SIGNAL CABLE

A. Instrumentation cable shall be stranded conductor, tinned copper, polyethylene insulated, aluminum polyester shield, stranded tinned copper drain wire, chrome PVC jacket, 100% shield coverage, 300V, 150°C

1. Single pair cable (1 TSP) shall be #16 gage, Belden, or equal.
2. Two pair cable (2TSP) shall be #20 gage, Belden, or equal.

B. Computer cable shall be RS-422, general purpose, 4-conductor, shielded.

#### 2.04 PORTABLE CORD

A. Portable cord shall be UL listed, Type SO for sizes No. 10 AWG and smaller. Cords with conductors larger than No.2 A WG shall be UL listed Type G. Cords shall contain an equipment grounding conductor. Cable characteristics shall be as follows:

1. Conductors: Flexible rope stranded per ASTM B 189 and B 33. Conductors shall be coated except ground conductors may be uncoated.
2. Insulation: Insulation shall be ethylene propylene as per ICEA S-68-516 and rated for continuous operation at 90 degrees C, 600V
3. Heavy-duty mold cured neoprene as per ICEA S-68-5 16.

#### 2.05 SPLICING AND TERMINATION MATERIALS

A. 600V Conductor and Cable Connectors
1. Connectors shall be I-piece tool applied compression type of required size, UL listed for the specific application. Connectors shall be tin-plated high conductivity copper. Connectors for wire sizes No. 10 AWG and smaller shall be nylon self-insulated ring tongue or locking-spade terminal. Connectors for wire sizes No. 8 AWG and larger shall be 1-hole lugs up to size No. 3/0 AWG, and 2-hole or 4-hole lugs for size No. 4/0 and larger. Mechanical clamp, dimple, screw-type connectors are not acceptable.

2. In-line splices and taps shall be used only with prior approval of the ENGINEER. When used, they shall be of the same construction as other connectors.

B. Portable Cable Fittings: Portable cable fittings for terminating the cable shall provide a watertight seal between the cord and the terminator and between the terminator and mounting hub. The cable terminator shall be provided with a neoprene liner which grips the cord jacket when the back nut on the fitting is tightened. In addition, on pendant cord applications and other applications where specified, a stainless steel wire mesh cord grip shall be provided as an integral part of the cord terminator.

C. Wire Markers: Each power and control circuit conductor size No. 10 AWG or smaller shall be identified as specified at each terminal to which it is connected with a legible permanent coded marking sleeve. Sleeves shall be hollow or white tubing, sized to fit the conductor insulation, with machine printed black marking, and shall be TMS Thennofit Marker System by Raychem Co., sleeve style wire marking system by W.H. Brady Co., Floy Tag and Mfg. Co., or equal. Adhesive strips are not acceptable. Conductors No. 8 AWG and larger shall be identified by cable markers of the locking tab type. Tabs shall be white plastic with conductor identification number permanently embossed.

PART 3 – EXECUTION

3.01 GENERAL

A. Cables crossing hinges shall be made up into groups not exceeding 12 and shall be so arranged that they will be protected from chafing when the hinged member is moved. These groups shall be protected by spiral wrap and have a minimum 12-inch loop.

3.02 WIRE AND CABLE TERMINATION

A. Power conductors No. 10 AWG and larger may be terminated directly in box-type lugs without terminals. Insulated terminals of the spade or ring-tongue type shall be used on all stranded control and power conductors No. 12 A WG and smaller. Insulated terminals shall be used also on all stranded instrumentation wiring special instrumentation cables shall be terminated in accordance with the recommendations of the manufacturer of the equipment and subject to acceptance of the ENGINEER.

B. No splices shall be used in power and control wiring continuous from point-to-point.

C. The wiring shall be all control conductors in instrument and relay compartments of motor control centers, in control panels, instrument panels, field panels and control stations as well as connections to mechanical equipment shall be tagged at each end with legible, permanently coded wire-marking sleeve showing the complete wire designation.
D. All field wiring to pushbutton stations and other isolated control devices shall be labeled at each end with the complete circuit number. All wiring to other panels, relay compartments of the same panel or interlocking wiring shall have the applicable double identification at each end of the conductors.

3.03 600- VOLT CONDUCTOR AND CABLE

A. Conductors in panels and electrical equipment, No.6 AWG and smaller, shall be bundled and laced at intervals not greater than 6 inches, spread into trees and connected to their respective terminals. Lacing shall be made up with plastic cable ties. Lacing is not necessary in plastic panel wiring duct.

B. Stranded conductors shall be terminated as described in Paragraph 3.02 except where terminals will not accept such terminations. In these cases, the conductors shall be terminated directly on the terminal block. Compressions lugs and connectors shall be installed using manufacturer's recommended tools.

3.04 PORTABLE CORD

A. Portable cord feeding permanent equipment, such as pumps, cranes, hoists and portable items shall have a wire mesh cord grip of flexible stainless steel wire to take the tension from the cable termination. Weatherproof strain relief fittings shall be used for all connections. Forty-five-degree and 90-degree connectors shall be used where applicable to prevent unnecessary strain on cords. Flexible cords feeding submersible motors shall be similarly protected, but the cord shall be of nonwicking neoprene construction.

– END OF SECTION –
SECTION 16150 – INDUCTION MOTORS

PART 1 – GENERAL

1.01 DESCRIPTION

Requirements specified in Conditions of the Contract, Section 16050 and Section 16100 form a part of this Section. This Section outlines the electrical requirements for squirrel-cage induction motors.

1.02 SUBMITTALS

Submit for the CITY’s approval shop drawings, factory test reports, manufacturers’ certified reports and technical data for motors supplied with driven equipment to the extent required in this Section, Section 16050 and the Specification Sections for mechanical equipment.

A. Shop Drawings. In addition to information to be included in the shop drawings as specified in Section 16050, shop drawings shall include the following:

1. Motor locked rotor and full load currents.
2. Power factors and efficiencies at full load, three quarters load and half load.
3. Motor housing material, winding material, NEMA Design letter, NEMA Code Letter, ambient temperatures and maximum elevations in which motor is designed to operate continuously, service factor, NEMA insulation Class, temperature rise, type of enclosure, voltage, bearing life and dynamic balance; all of which shall comply to the requirements of the specifications.
4. Nameplate data.
5. Dimensions and weights of motors.
7. Speed torque/current at 100 percent volts.
8. Wiring diagrams, internal and typical external connections.
9. Letter or standard motor manufacturer’s literature confirming that motor (or motors) are designed for use with adjustable frequency drives/SCR drives.
10. Time-current damage curves, plotted on full size log-log paper for motors 100 horsepower and larger.

B. Current Data. Submit eight copies to the CITY of field recorded current data. The data shall indicate the full load current for each motor, and current rating for the overload relay in each motor starter and controller.
PART 2 – PRODUCTS

2.01 GENERAL

Motors shall be supplied by the manufacturer of the driven equipment as specified in this section, and specifically outlined in the driven equipment specifications. The Motors shall be completely fabricated, assembled, checked and tested at the factory in accordance with NEMA MG-1. The induction motors shall be Baldor, General Electric, Toshiba, Reliance, Siemens, and U.S. Electrical Motors.

A. Motor Ratings.

1. Torque and slip characteristics shall be as recommended by the manufacturer of the driven equipment and as specified. Motor manufacturer shall confirm motor capability to the specifications.

2. Motors shall have a continuous rating and shall operate continuously and satisfactorily in ambient temperatures from minus 10 degrees Celsius to plus 40 degrees Celsius at a maximum elevation of 3,300 feet without exceeding nameplate horsepower rating.

3. The motors shall have high power factor and the minimum power factor shall be 80 percent at full load.

4. Motors shall be designed for high efficiency. Motors with the following minimum efficiencies, at full load, shall be provided:

   a. 84 percent minimum efficiency shall be provided for motors through 5 horsepower.

   a. 87.5 percent minimum efficiency shall be provided for motors 7-1/2 through 15 horsepower.

   b. 91 percent minimum efficiency shall be provided for motors 20 through 40 horsepower.

   c. 93 percent minimum efficiency shall be provided for motors 50 through 125 horsepower.

   d. 95.4 percent minimum efficiency shall be provided for motors 150 to 400 horsepower.

5. The motors shall be sized so that the maximum BHP of the load does not exceed 90 percent of the full load nameplate horsepower of the motor unless otherwise indicated in the driven equipment specifications.

6. The motor must be able to accelerate the driven machine from zero to top speed at 90 percent of rated voltage without overheating.

7. The maximum locked rotor KVA/HP code letter for motors smaller than 15 HP shall not exceed the requirements for NEMA Design B motors. The maximum locked rotor KVA/HP code letter shall be Code G for motors 15 HP through 250 HP unless otherwise indicated. The maximum locked rotor KVA/HP code letter shall be Code F for motors 300 horsepower and larger unless otherwise indicated.
8. All motors shall be insulated and braced for full voltage across the line starting regardless of the starting method used.

9. Motors 1/2 HP and larger shall be NEMA MG1-1.16 Design B and shall have NEMA MG1-1.66 Class F insulation, minimum.

10. The temperature rise by resistance above the temperature of the cooling medium, for each of the various parts of the motor shall not exceed the values of the NEMA MG1-1.66 Class B insulation system as indicated in NEMA MG 1-12.43.

11. All motors shall have a 1.15 service factor at the specified maximum ambient temperature

12. Motors 1/2 HP and larger shall be 460 volts, 3 phase, 60 Hertz unless otherwise indicated.

13. Motors smaller than 1/2 HP shall be 115/230 volts, 1 phase, 60 Hertz unless otherwise indicated.

14. Motors for variable speed application equipped with adjustable frequency drive controller shall be of the inverter duty type with winding temperature switches for alarm and shutdown application. The permeate pump and air scour blower motors shall be inverter duty type with winding temperature switches for alarm/shutdown applications.

B. Motor Construction.

1. Enclosures for induction motors shall be approved for the installations and as indicated. The enclosure types shall be one of the following as outlined in the driven equipment specifications unless otherwise indicated.

   a. Weather Protected 1.

   b. Totally-enclosed fan cooled.

2. Housing, end brackets and all outside components shall be cast iron.

3. A condensate drain hole shall be provided on all non explosion-proof enclosed motors. The drain hole shall be provided in each end bracket on horizontal motors. A single drain hole shall be provided in the lower bracket of vertical motors.

4. The motors shall be equipped with terminal boxes for all conduit and wire connections as required.

   a. The terminal boxes shall be properly sized, diagonally split, cast iron, and rotatable in 90-degree steps. Provide a gasket between the box and motor frame and between the box and the cover. Terminal boxes shall be attached to the motor frame with grade 5 zinc plated and chromated steel bolts or cap screws. All terminal boxes shall have threaded holes for conduit entrance.

5. The castings shall be coated with a red-oxide zinc-chromate primer, and finished with a corrosion resistant epoxy coating. All fabricated steel enclosures shall be coated on all inside and outside surfaces except shafts and register fits.

6. Provide stainless steel nameplates of ample size with clear numerals and letters.
a. Nameplates shall indicate the manufacturer, serial number, model number, type, horsepower, phase, hertz, volts, design, full load amperes, locked rotor code letter, service factor, speed, insulation class, temperature rating, information required by NEMA MG 1-10.39, NEMA MG 1-10.40 and other essential data.

b. Nameplate data shall be in the English language and units.

c. Nameplates shall be secured to the motor frame with corrosion resisting pins in accessible locations.

7. Ground lugs shall be provided in all main motor terminal boxes for grounding.

8. All motors shall have copper windings.

9. Antifriction bearings shall be grease lubricated except for vertical high thrust motors which may require oil lubrication.

a. Grease lubricated bearings shall include accessible fittings for in-service, periodic re-lubrication.

b. Oil lubricated bearings shall be a reservoir type with a sump for settling foreign matter, accessible and exterior fill and drain plugs and a visual oil level indicator with maximum and minimum indicator levels.

c. Horizontal, direct connected motor bearings shall be designed for 1 year minimum B-10 bearing life at NEMA minimum V-belt criteria for the rating.

d. Horizontal, V-belt connected motor bearings shall be designed for 3 year minimum B-10 bearing life for the application V-belt drive or 1 year minimum B-10 bearing life at NEMA minimum V-belt criteria whichever is more restrictive.

e. Vertical motor bearings shall be designed for 2-year minimum B-10 bearing life at design operating thrust. At maximum operating thrust, B-10 life shall not be less than one year. Transient (shut-off) thrust shall not exceed 30% of the static deformation limit. Motor shall be designed for 30% momentary upthrust capacity except 3,600 RPM units, which must have 30% continuous upthrust capacity. Any system, which exceeds 30% upthrust must be designed for continuous upthrust at one year B-10 bearing life.

f. Pre-lubricated, double shield bearings are acceptable only on single phase and 56 frame motors.

10. The dynamic balance of motors built in frame size 143 and larger shall be 0.001 inches total amplitude or peak-to-peak displacement.

11. Accessories shall include the following:

a. Space heater shall be provided for all outdoor motors and motors installed in confined and damp location. The space heater shall be 120 volt, 1 phase, and adequately sized to raise the temperature inside the motor to a minimum of 6 degrees Fahrenheit above ambient and provide temperature switches on the windings for alarm and shutdown functions.

b. For motors 200 HP and larger provide temperature sensors in stator windings of pump motor. Six (6) RTD type temperature sensors shall be provided.
c. For motors 200 HP and larger provide temperature sensors in pump motor's
bearings. Two (2) RTD type temperature sensors shall be provided.

12. Motors shall have a guaranteed maximum noise level in accordance with NEMA
MG1-12.49 for integral horsepower motors and NEMA MG1-20.50 for large motors,
except where more restrictive requirements are outlined in other Sections of the
Specifications.

PART 3 – EXECUTION

3.01 GENERAL

Provide all the equipment installations and wiring installations, including connections as
indicated, specified and required. Assure proper fits for all equipment and materials in the
spaces as shown on the Drawings.

A. Motors.

1. Provide power, control, alarm, and grounding installations for all motors as indicated
and required.

2. Check the connections and provide correct rotation for all motors.

3. Record the full load current to each motor, and the overload relay rating in each
motor starter for the certified data submittal.

4. Provide the wiring for heaters in the motor frames and the required controls to de-
energize the heater when the motor operates.

5. Provide the required wiring for all control equipment that shall be furnished and
installed by other Sections of the Specifications.

6. Install the motor control stations as shown on the Drawings.

7. Field damaged factory finish on equipment shall be touched-up with paint that is
equal in quality and color to the original factory finish.

3.02 FACTORY TESTS

A. All Motors shall be given a standard commercial test as defined by NEMA MG 1-12.51
and IEEE 112 a and b.

B. Conduct megger test and record reading of all motor windings just prior to connecting
the motor to its feeder to determine if accumulation of moisture has occurred in the
motor during storage. The reading shall be documented, submitted to the ENGINEER
for review, and included in the final Operation and Technical Manuals.

C. Noise Tests shall be determined by measurement in accordance with the latest
revision of IEEE-85, Test Procedure for Air Borne Noise Measurements and Rotating
Electrical Machinery. The motor shall be operating during test on rubber at no load
with rated voltage and frequency.

D. Vibration Tests shall be per NEMA MG 1-12.07 for small and medium motors and MG
1-20.54 for large motors, except 3,600 RPM motors greater than 250 horsepower and
motors with sleeve bearings shall be tested at full nameplate horsepower load and temperature.

E. All Testing, other than locked rotor conditions shall be at full voltage ±5 percent.

3.03 FIELD CHECKS

A. Motor Installations shall be complete and correct.

B. Operation Tests shall be performed to observe that motors start, run and stop satisfactorily under design load.

– END OF SECTION –
SECTION 16480 – LOW-VOLTAGE MOTOR CONTROL CENTERS

PART 1 – GENERAL

1.1 WORK OF THIS SECTION

A. The CONTRACTOR shall provide motor control center (MCC), complete and operable, in accordance with the Contract Documents.

B. The requirements of Section 16050 - Electrical Work, General, apply to the WORK of this Section.

C. The requirements of Section 16455 – Variable Frequency drives (VFD) and Section 16481 – Solid-State Reduced voltage Starters (SRVS), where VFD and SRVS are shown on the motor control centers, also apply to the WORK of this Section.

D. In the event that motors provided are larger horsepower than motors indicated, raceways, conductors, starters, overload elements, and branch circuit protectors shall be revised as necessary to control and protect the increased motor horsepower according to Section 16460-Electric Motors. Adjustments shall be made at no increase in cost to the OWNER.

1.2 REFERENCES

A. The MCC shall meet or exceed the requirements within the following standards.

   1. NEMA ICS 1-322.
   2. NEMA ICS 2-322.
   3. UL 845.
   4. UL 489
   5. NEC NFPA 70

1.3 QUALITY ASSURANCE

B. Manufacturer of the MCC shall be the manufacturer of the motor starters including across the line starters, solid-state starters and variable frequency drives, as required on this project.

1.4 ENVIRONMENTAL REQUIREMENTS.

A. The MCC enclosure shall be suitable and rated for the environment where MCC is to be located.

B. The environmental conditions shall be as stated in Section 16050 – Electrical Work, General.

1.5 CONTRACTOR SUBMITTALS

A. Submittals shall be in accordance with Sections 01300-Contractor Submittals and 16050 – Electrical Work, General.
B. Shop Drawings

1. Enclosure NEMA rating and color
2. Horizontal and vertical bus ampacity, voltage rating and interrupting capacity. Include materials of construction
3. Ground bus size and material of construction
4. Conduit entrance provisions
5. Main incoming line entry provision (top or bottom)
6. Control unit nameplate schedule
7. All circuit breaker types, frames and settings
8. All starter NEMA sizes, auxiliary contact provisions, coil voltage
9. Relays, timers, pilot devices, control transformer VA and fuse sizes
10. Elementary schematic ladder diagrams for each compartment. Custom schematics shall be furnished. Diagrams shall include all remote devices. Submittals with drawings not meeting this requirement will not be reviewed further and will be returned to the CONTRACTOR stamped "REJECTED".
11. Wiring within each, interconnection between units and identification of terminals.
12. Short circuit rating of the complete assembly
13. Replacement parts lists and operation and maintenance procedures
14. Seismic design certification of the anchoring system in accordance with 16050 - Electrical Work, General
15. Time-current curves for all protective devices
17. Recommended spare parts list.

PART 2 – PRODUCTS

2.1 GENERAL

A. The manufacturer of the low voltage motor control center shall also be the manufacturer of at least the following items
   1. Molded case circuit breakers up to and including 225 ampere frame size
   2. Disconnect switches

B. Devices of the same type shall be products of the same manufacturer. This requirement applies to all control devices, and insofar as practical, to equipment manufactured on a
production basis. It also applies without exception to equipment custom fabricated for this project.

C. Motor control centers shall be Class 11, Type B wiring.

D. The motor control center shall be approved for “Suitable for Use as Service Entrance Equipment”.

2.2 DESIGN, CONSTRUCTION, AND MATERIAL REQUIREMENTS

A. The motor control centers shall be 600-volt class suitable for operation on a three-phase, 60-Hz system. The system operating voltage and number of wires shall be as indicated.

B. The motor control center shall receive power from a three-phase, wye-connected 480Y/277 volt with a grounded neutral. Power distribution from the MCC shall be 480 volt, three-phase, three-wire, however, the MCC shall include provision for termination of an incoming neutral conductor in conformance to NEC requirements for service entrance.

C. The motor control center shall be approved for use as “Service Entrance Equipment.

D. The integrated short-circuit interrupting rating of the MCC assembly shall be 65,000 ampere RMS symmetrical unless otherwise shown on the drawings.

E. Compartment doors shall be interlocked with compartment circuit breakers. The interlock shall be fitted with a maintenance override and padlocking provision.

F. Size and Arrangement

1. Motor control centers shall be of mechanical groupings of control center units, assembled into a lineup of control center sections. Each control section shall be nominally 90 inches tall by minimum 20 inches deep.

2. MCC shall be designed not to exceed the space requirements as indicated on the Contract Drawings, including spaces, spares and future compartments. MCC shall be subject to rejection for exceeding the lengths shown where allotted space is critical.

3. Provision for the future addition of sections shall be included so that matching sections of the same current rating can be added without the use of transition sections.

4. Equipment within the MCC may be rearranged at the discretion of the manufacturer, providing the MCC provides the spares, space and future provisions indicated.

G. Components

1. Buses shall be as follows:

   a. The main horizontal bus shall be copper, tin, or silver-plated copper located within an isolated compartment. The bus shall be rated 600 amperes minimum, but in no instance less than the main lug or main breaker frame size.
b. The vertical bus in each section shall consist of a single silver-plated copper conductor per phase with a current capacity of not less than 300 amps and shall be sized to satisfy the connected load requirements. The vertical bus shall be completely isolated and insulated, and shall extend the full height of the section wherever possible.

c. The bus arrangement shall be A, B, C from top to bottom and left to right.

d. A continuous copper ground bus shall be provided with full width of the motor control center line-up. In addition, vertical ground busses can be installed per manufacturer’s standards.

e. Fully rated continuous copper neutral bus shall be provided through the control center where 4-wire systems is specified or shown. Lugs of appropriate capacity shall also be provided.

f. All power buses shall be braced to withstand minimum 65,000 amperes RMS symmetrical unless otherwise indicated elsewhere.

g. The temperature rise of the busses shall be per NEMA standards.

2. A separate vertical wireways shall be provided adjacent to each vertical unit, and shall be covered by a hinged door. Each individual unit compartment shall be provided with a side barrier to permit pulling wire in the vertical wireway without disturbing adjacent unit components.

H. Cabinet

1. Structural members shall be fabricated of not less than 12 gauge steel and side and top panels and doors shall be not less than 14 gauge steel.

2. Spaces designated as "SPACE" or "BLANK" shall include blank hinged doors and vertical bus bars.

3. Control units inside compartments shall be clearly identified with tags or stencil markings.

4. Each control unit including spares, spaces, and blanks, lights and devices shall be identified by an engraved nameplate. Identification shall include circuit number as indicated.

5. Each motor control center shall be fitted with the manufacturer's nameplate which shall include the NEMA Standard electric rating and other pertinent data, including sales order number, date of manufacturer, and place of manufacture.

6. Where "L" or "U" shaped MCC layouts are indicated or required, corner compartments shall be installed and shall have similar current and short circuit ratings as functional compartments.

7. Finish for motor control center shall be light gray, ANSI 61. The panels shall be given two coats of primer inside and out and two coats of enamel finish. External colors other than ANSI 61 is not acceptable.
2.3 MAIN AND FEEDER CIRCUIT BREAKERS

A. All circuit breakers shall be molded-case or insulated-case circuit breaker and shall be UL listed for application in their intended enclosures and shall have a minimum 65,000 amperes interrupting rating at system voltage unless otherwise specified or indicated. Current-limiting circuit breakers are acceptable.

B. Insulated-case circuit breakers shall be manually operated fixed-mounted front access type with stored energy mechanism.

C. Series rated circuit breakers shall not be acceptable unless approved by the ENGINEER.

D. Molded-case circuit breakers having a frame size of 250 amperes or less shall be thermal magnetic type and shall be 80 % rated.

E. The molded-case circuit breakers with a frame size larger than 250 ampere and all insulated-case circuit breakers shall be 100 % rated and shall be provided with a microprocessor-based, self-contained RMS Solid-Sate Trip Unit specified in Para. 2.4. The circuit breakers shall be provided with the following:
   1. Long-time pickup with long delay time.
   2. Short-time pickup and short delay time.
   3. Instantaneous.

F. Provide circuit breaker accessories where indicated on the drawings

2.4 RMS SOLID-STATE TRIP UNIT –GENERAL

A. The RMS Solid-State Trip Unit system shall consist of three (3) current sensors for 3-wire, 3-phase system, four (4) sensors for 3-phase, 4-wire system, a trip unit and a flux-transfer shunt trip. The trip unit shall use microprocessor-based technology to provide the adjustable time-current protection functions.

B. The microprocessor based trip unit shall be self-contained and shall not require an external power for operation when the circuit breaker is in closed and the current is flowing through the circuit. The control power will be obtained from current sensors mounted in the breaker.

C. The interchangeable rating plug shall be provided to match the frame size of the circuit breaker unless otherwise shown. Rating plug shall be fixed or adjustable as required. The rating plug shall house a long life lithium battery to provide power to the trip unit LED to indicate circuit breaker trip and loss of control to the module. A battery test button shall be provided.

D. The trip unit shall contain an integral test panel with a test selector switch and a test pushbutton. The test selector switch shall enable the user to select the values of test current within a range of available settings. The basic protection functions shall not be affected during test operations.
E. For trip units without an instantaneous adjustment, a discriminator circuit shall be provided to prevent the breaker being closed and latched on to a faulted circuit.

F. The front adjustable trip unit shall have multiple time-current settings that are set from the front of the circuit breakers.

G. The system coordination shall be provided by the following microprocessor-based time-current curve shaping adjustments:

Protection:

Adjustable long delay pickup (L).
Adjustable long delay time
Adjustable short delay pickup (s).
Adjustable short delay time (with I2T)
Adjustable ground fault pickup (G).
Adjustable ground fault delay time (with I2T)
Adjustable Instantaneous pickup (I).

Some of the above functions may be deleted or disabled when the protection coordination study indicates that the complete selective protection is provided without such functions.

H. LED display shall be provided to indicate the following data:

Cause of trip
Instantaneous value of maximum phase and ground current
Level of fault current that initiated an automatic trip operation

I. The following Monitoring and digital display shall be provided.

Current
Voltage
Present KW, Maximum Demand KW, Kilowatt Hour.
Power factor.
Harmonics if indicated

J. Instrument Transformer

Voltage and current instrument transformers required for protection and monitoring shall be provided even if they are not shown on the drawings.

For 3-phase, 4-wire system, provide a neutral current transformer.

K. Communication:

Communication capability with Plant PLC specified in Division 13 – Instrumentation. Where required, interface modules shall be provided.

L. The RMS solid-state trip unit shall be General Electric “MicroVersa” trip units, Square D “Micrologic” trip units, or equal.

2.5 MOTOR STARTERS

A. All motor starters shall be rated for fault current of 65,000 amperes unless otherwise shown on the drawings.
B. Motor starters shall be mounted in standard motor control center assemblies, arranged as indicated.

C. Each motor starter unit shall consist of a combination magnetic contactor and short circuit protective device, mounted in a completely enclosed cubicle. Short circuit protective device shall be an instantaneous, magnetic only circuit breaker, G.E. Mag-Break, Cutler-Hammer Motor Circuit Protector (MCP), or equal. All circuit breakers provided as part of a motor starter unit shall be capable of being padlocked in the open position. Reset of thermal overload elements shall be possible with unit door closed. Three phase overload trip units shall be furnished to suit the full load current of the equipment installed. Overload trip unit shall be adjusted as required for power factor correction capacitors.

D. Magnetic starters shall have auxiliary contacts as required by electrical motor control diagrams including N-O and N-C contacts as indicated, plus one each spare N-O and N-C contact. The combination motor starters shall be plug-in-type for size 4 and below. The fixed-type unit assembly shall be constructed so that it can be easily removed from its panel after disconnecting the wires to the terminal block and withdrawing from the primary bus. Removal of a unit assembly shall be possible without rear access and without disturbing any other unit in the motor control center.

E. Each starter unit shall have its own control power transformer. It shall have a 115-volt grounded secondary. One secondary fuse and 2 primary fuses shall be provided. Control power transformers shall be sized to accommodate the control devices indicated.

F. Local control devices shall be mounted independently of the cover door. All starters shall have a red "running" and a green "off" lights to indicate the presence of control power when the motor is not running. Starters shall be provided with elapsed time meters, hand/off/auto selector switches, and other devices where indicated. All cubicle control wires shall be terminated at a pull apart disconnecting terminal block at the cubicle.

G. The motor control center manufacturer shall be responsible for identifying each control wire within each motor starter unit with wrap-around permanent plastic markers. Each control wire shall be identified at both ends.

H. Full voltage motor starter units shall be NEMA Size 1 or larger. The combination starters shall be rated for a minimum, 65,000 RMS symmetrical amperes.

I. Motor starters shall be designed to NEMA ratings. Starters designed to IEC ratings or with dual IEC/NEMA ratings will not be acceptable, either as part of any MCC, as remote starters, or as part of any equipment package unless approved by the ENGINEER.

J. All starters shall have three phase overload relays and shall be ambient compensated with manual reset.

K. Reduced voltage auto-transformer starters shall consist of a molded-case motor circuit protector in combination with a closed transition type auto-transformer starter with 50 percent, 65 percent, and 80 percent taps, and shall be set on the 65 percent tap. The starter shall have three phase overload relays, and shall be ambient temperature-compensated with manual reset. The auto-transformer shall include a thermal switch.
wired to protect itself from overheating. Timing of the starting period shall be controlled by an adjustable accelerating relay.

L. Two speed starters shall be of the one-winding or two-winding type as shown on the single-line diagrams.

M. Lighting panel and transformer shall be installed as shown on the diagrams and shall meet the requirements specified in Section 16470 – Panelboards and Section 16330 – General Purpose Dry-Type Transformers.

N. Automatic transfer switches shall be provided where shown and the ATS shall meet the requirements of the Section 16495 – low-Voltage Automatic Transfer Switches.

O. Solid-state reduced voltage starters (SRVS) shown installed in the motor control center structures shall meet the requirements specified in Section 16481 – Solid-State Reduced Voltage Starters.

P. Variable frequency drives (VFD) shown installed in the motor control center structures shall meet the requirements specified in Section 16455 – Variable Frequency Drives.

2.6 SPARES AND SPACES

A. When spares are specified or shown on the drawings, spare combination motor starters with the sizes indicated shall be provided. The basic control wiring including indicating lights, overload relays or as shown on the control schematic diagrams shall be provided.

B. When spaces are indicated on the drawings, compartment spaces shall be provided with mounting back panels for future installation of various sizes of starters or control devices.

2.7 MOTOR PROTECTION RELAY (MPR)

A. Where indicated on the drawings, a microprocessor based motor protection relay shall be provided for each motor. The MPR shall be powered from the control power transformer furnished with the starter.

B. MPR shall read the true RMS current into the motor and shall provide the motor protection and metering functions.

C. The relay shall provide the following protection, metering and monitoring functions as a minimum:

1. Protection.
   a. Overload (51) & short-circuit (50).
   b. Overload lockout (86)
   c. Starts/hour & time between starts (66)
   d. Restart block (Anti-Backspin timer).
   e. Current balance (46).
   f. Ground fault & ground fault backup (50G/51G).
2. Metering and monitoring:
   a. Amp (A), Watt (W), Reactive VA (var), Volt-Amp (VA), Power Factor (PF), frequency (Hz)
   b. Watt-hour (Wh), Reactive VA Hour (varh), Torque,
   c. Demand: Amp (A), Watt (W), Reactive VA (Var), Volt-Amp (VA) Peak.
   d. Temperature (RTD).

D. MPR shall be provided with a capability to transmit or receive all information in the software through a serial communication with the PLC and Remote I / O unit specified in the specification Division 13.

E. Instrument transformers for the protection relays shall be provided where required.

F. MPR shall be Multilin SR 469, SEL-701011X, or equal.

2.8 CONTROL DEVICES AND METERING

A. All control devices shall conform to the requirements of Section 16050 – Electrical Work, General.

2.9 ENCLOSURE.

A. Conduit entries shall be bottom, top or both as shown on the drawings.

B. The motor control center exterior finish shall be ANSI 61.

C. The motor control center located indoor shall be NEMA type 12 unless the NEMA type 1.

D. Motor control center located outdoor and indicated or shown as NEMA 3R Walk-in type enclosure shall be provided with the following:
   1. Aisle lights with 3 way switches and GFCI receptacles.
   2. Thermostatically controlled space heater in each section of the motor control center.
   3. Panic door with door lock.
   4. Top and sides insulation with 1 inch foam.
   5. Side ventilation with top fan and bottom filtered louver unless air conditioner is provided.
   6. Corrosion resistant undercoat.
7. Air conditioners, where specified or shown on the drawings, shall be provided to maintain the interior temperature of 86 degree F maximum at the exterior ambient temperature of 115 degree F.

2.10 FACTORY TESTS

A. All motor control centers and their components shall be given Manufacturer's standard electrical and mechanical production tests and inspections. The tests shall include electrical continuity check, dielectric tests for each circuit, and inspection for proper functioning of all components including controls, protective devices, metering, and alarm devices.

2.11 SPARE PARTS

A. The CONTRACTOR shall furnish the following for each MCC:
   1. One unit control transformer of each size furnished in magnetic starters installed
   2. Three bezels of each color installed for pilot indicators
   3. One dozen panel lamps
   4. One dozen control fuses of each size installed

B. Spare parts shall be identified by MCC number, type, size, and manufacturer.

2.12 MANUFACTURERS OR EQUAL

A. Motor control centers shall be General Electric, Square D, Cutler-Hammer, Allen-Bradley, or equal.

PART 3 – EXECUTION

3.1 GENERAL

A. The CONTRACTOR shall install motor control centers in accordance with Manufacturer's published instructions. Conduit installation shall be coordinated with Manufacturer's-as-fabricated drawings so that all conduit stub-ups are within the area allotted for conduit. Conduit shall be stubbed up in the section that contains the devices to which conductors are terminated.

B. If stored at the site, motor control centers shall be stored in a clean, dry space. Factory wrapping shall be maintained or an additional heavy plastic cover shall be provided to protect units from dirt, water, construction debris, and traffic. Storage space shall be heated or MCC space heaters shall be energized.

C. Motor control centers shall be handled carefully to avoid damage to motor control center components, enclosure, and finish. Damage shall be repaired before installation.

3.2 INSTALLATION

A. Motor control centers shall be installed on 4-inch concrete pads. After leveling and shimming, the CONTRACTOR shall anchor motor control centers to concrete pads, and shall grout so that no space exists between the pad and support beams.
B. The CONTRACTOR shall:

1. Torque all bus bar bolts to Manufacturer’s recommendations; tighten all sheet metal and structure assembly bolts.

2. Adjust all Motor Circuit Protector (MCP) devices to the instantaneous trip setting position recommended for the actual horsepower and full load amps of the motor. Verify that overload devices are proper for equipment installed; make necessary changes in overload devices as required for motors having power factor correcting capacitors.

3. After equipment is installed, touch-up scratches, and verify that nameplate, and other identification is accurate.

4. Furnish and install high voltage switchboard matting in front of the MCC. The mat shall be 1/4 inch thick and 36 inches wide and shall be Model M36 as manufactured by W.H. Salisbury & Co., or equal.

3.3 FIELD TESTS

A. Visual and mechanical inspection after installation

1. Inspect for physical damage, proper anchorage and grounding.

2. Verify that the ratings of the thermal overload heaters match the motor full-load current nameplate data.

3. Check tightness of bolted connections.

B. Electrical tests

1. Insulation tests

   a. Measure insulation resistance of each bus section phase to phase and phase to ground for one minute. Test voltage and minimum acceptable resistance shall be in accordance with Manufacturer’s recommendations.

   b. Measure insulation resistance of each starter section phase to phase and phase to ground with the starter contacts closed and the protective device open. Test voltage and minimum acceptable resistance shall be in accordance with the Manufacturer’s recommendations.

   c. Measure insulation resistance of each control circuit with respect to ground.

2. Verify proper operation of control logic in all modes of control.

– END OF SECTION –
SECTION 16481 – LOW-VOLTAGE SOLID-STATE MOTOR STARTER

PART 1 – GENERAL

1.1 THE REQUIREMENT

A. This specification covers the design, fabrication, performance, testing, delivery, and installation of the Low-Voltage Solid-state Reduced Voltage Motor Starter (SSRVS) specified herein. The CONTRACTOR shall provide the Low-voltage Solid-state Reduced Voltage Motor Starters, complete and operable, in accordance with the Contract Documents.

B. All components, testing and services specified or required for a complete system shall be included. The CONTRACTOR shall bear the responsibility that the equipment has been designed and fabricated in accordance with all codes, standards and governmental regulations applicable and performs under the conditions and to the standards specified herein.

C. The information included in this specification and drawings is intended to describe the general design, performance, interface characteristics and construction features of the equipment. The accuracy of the CONTRACTOR furnished data and information, and the compatibility of such information with the overall performance of the equipment shall be the sole responsibility of the CONTRACTOR.

D. The solid-state reduced voltage motor starters shall be UL listed and labeled.

E. The requirements of Section 16050 - Electrical Work, General, Section 16480 – Low-Voltage Motor Control Center and Section 16460 – General Purpose Induction Motors, apply to the WORK of this Section.

F. The CONTRACTOR shall furnish all tools, equipment, materials, and shall perform all labor as required for designing, furnishing, installing, and testing of all SSRVS, including accessories as indicated on the drawings and specifications herein.

1.2 REFERENCE CODES AND STANDARDS

A. REFERENCE CODES.

All work specified herein shall conform to or exceed the applicable requirements of the National Electrical Code (N.E.C.); provided, that where a local codes or ordinances is in conflict with N.E.C., the said local codes or ordinances shall take precedence. For additional requirements, see paragraph “Reference Standards “of Section 16050 - Electrical General Provisions.

B. APPLICABLE PUBLICATIONS:

1. NFPA National Fire Protection Association
2. NEC National Electrical Codes
3. UL Underwriters Laboratories, Inc.
4. IEEE Institute of Electrical and Electronic Engineers Association
5. ANSI American National Standards Institute
6. ANSI C57.13 Requirements for Instrument Transformers
7. ANSI Z55.1 Gray Finishes for Industrial Apparatus and Equipment
1.3 CONTRACTOR SUBMITTALS

A. The CONTRACTOR shall submit shop drawings of all starter (centers) and components in accordance with the requirements of Section 01300 – CONTRACTOR SUBMITTALS, and the additional requirements specified herein.

1. Name of the starter manufacturer.
2. Certified starter outline drawings.
3. Engineering data to include voltage, continuous current, withstand and interrupting rating.
4. Material list and catalog cuts.
5. Seismic design of anchoring system.
6. Certified factory design test reports.
7. Recommended spare part list.
8. Complete list of tools for the operation and maintenance of the units.

B. The following technical data shall also be submitted:

1. Complete one-line diagrams and assembly ratings including:
   a. Short-circuit rating
   b. Voltage
   c. Continuous current
   d. Control diagrams
   e. Protection functions and features.

2. Schematic diagrams showing the circuit design and connections of all electrically controlled and operated devices, and systems including those which are located remotely from the equipment specified in this specification but form the part of controlling equipment to be furnished under this specification.

3. Catalog cut and brochures.
1.4 WARRANTY AMD QUALITY ASSURANCE

A. GENERAL

All materials shall be new, tested and inspected in accordance with Section 16050 - Electrical Work, General and other requirements specified herein.

B. WARRANTY

The system warranty shall be not less than one year after the initial commissioning of the equipment and shall include all costs for proper repair, parts, labor, and travel and living expenses.

C. STORAGE

The motor starters shall be stored in a clean, dry space. Factory wrappings shall be maintained, or heavy plastic cover shall be provided to protect units from dirt, water, construction debris, and traffic. Storage space shall be heated, or space heaters shall be energized.

D. FACTORY TESTING

1. The following standard factory tests and checks shall be performed on the equipment provided under this specification. All tests shall be in accordance with the latest version of ANSI and NEMA standards.

2. Sequence of control circuits check.

3. Style/part no of components check.

4. Wiring check.

E. Certified complete test reports shall be furnished listing all required tests, instruments, calibration dates and the results of each test for the starter. Each test report shall clearly state that the equipment tested and supplied is in conformance with all applicable Codes and Standards. Test reports shall include records of all test failures, repairs, reworks, or corrective actions, and re-tests.

F. SEISMIC TESTING.

Certified test results shall be available as part of design testing. The manufacturer shall certify that the completed starter assemblies will perform all normal functions without interruption or failure while under or after the effects of the specified seismic shocks.

1.5 ENVIRONMENTAL CONDITIONS

A. The motor starters shall be designed for continuous service in the environmental conditions specified herein:

1. Ambient Indoor Temperature 0 to 40 degree C (32 to 104 degree F)
2. Ambient Outdoor Temperature -7 to 50 degree C (20 to 122 degree F)
3. Humidity 0 to 95 % non-condensing (relative)
4. Elevation Less than 3,300 feet
5. UBC Seismic Zone          Zone 4
6. Wind speed                100 mph

1.6 OPERATION AND MAINTENANCE

A. The CONTRACTOR shall submit a recommended spare part list and shall furnish them. The CONTRACTOR shall submit operation and maintenance procedure for review. The data sheets shall be supplemented by written texts and shall include the following:
   1. Operation procedures.
   3. Manufacturers’ part list, illustration, assemblies and diagram.

1.7 SPARE PARTS

A. Provide two (2) of each size and rating of fuses.

1.8 MANUFACTURER

A. Motor starter(s) and assemblies shall be Square D, Allen-Bradley, Cutler-Hammer, General Electric, DNH Industries Inc., or equal.

1.9 SERVICE OF MANUFACTURER.

A. An authorized service representative of the manufacturer shall visit the site for not less 2 days each site to perform the following services;
   1. Verify proper installation of the equipment.
   2. Inspection, checking and adjustment of the equipment.
   3. Startup and field testing of the equipment.
   4. Authorized service representative shall instruct the Owner’s personnel in all aspects of starter operation and maintenance, including step - by - step trouble shooting procedures with necessary test equipment. Instruction shall be given after the motor starter is in place and in full service conditions.

PART 2 – PRODUCTS

2.1 GENERAL

A. The Low-voltage Solid-state motor starters shall be factory assembled and tested to the greatest extent practical and possible to minimize filed erection. All components used shall be UL listed or recognized.

B. This specification is not intended to set forth all details of design, fabrication. The CONTRACTOR shall have full responsibility for design, fabrication, and test and inspection procedures to ensure that the equipment provided shall comply with all regulatory codes, standards, and regulation applicable to the specified services, and shall operate satisfactorily as intended and in the environment specified in this section, and as specified and shown on the drawings.
C. The starters shall be provided with all the components, control, and functions to successfully control induction as specified and shown on the drawings.

D. Starters shall be mounted in the motor control center lineup as shown on the drawings.

2.2 RATING

A. The motor starters shall be designed for operation on a 460 volt, three-phase, 60 Hz, solid grounded systems.

B. The starters shall have an integrated interrupting rating of 65,000 ampere RMS symmetrical unless otherwise indicated on the drawings.

2.3 STARTERS

A. The starter shall be a solid-state reduced voltage starter and designed to accommodate motors of the size and the type as shown on the drawings.

B. The starter shall consist of a door interlocked main circuit breaker with padlockable device, SCR power module, bypass contactor, control power transformer, current and voltage transformers where required, motor protection, metering device, control logic, and other required ancillary.

C. The control shall be by microprocessor-based and a door mounted keypad programming/display module shall be provided for programming, monitoring, and metering parameters.

D. The control shall be designed to perform all the control and shall continuously monitor motor and starter operation for faults. If a fault is detected, the control logic provides the fault indication via LCD display and/or via communication port.

E. Each phase of the SCR power module shall be arranged in inverse parallel pairs of matched devices and in strings to facilitate sufficient PIV ratings for the applied voltage. The power section shall be capable of providing Maximum torque per amp throughout the motor’s speed-torque curve without external feedback signal. The transient voltage protection using RC snubber networks shall be provided for each phase SCR power module.

F. Each starter shall be provided with a control power transformer to handle the entire load

G. The starters shall be provided with the ancillary items as shown on the drawings.

H. Bypass contactors with thermal overload relays shall be provided. A sequencing feature shall control the contactors. The bypass contactors shall be rated to be capable of emergency across-the-line start.

2.4 PARAMETER PROGRAMMING

A. Keypad shall provide the following programmable control adjustments as a minimum:

1. Motor full load amp: Programmable to match motor full load Amp.


3. Current limit: 100 – 600 % of motor full load setting.
4. Adjustable initial current.
5. Initial torque setting adjustable from 0 to 90 % of the locked rotor torque.
7. Pulse start: A “kick-start” of 0 - 2.0 seconds at 550 % of motor full load rating for high inertia/breakaway torque loads.
8. Adjustable time between starts
9. Selection of Class 10, 20 or 30 protection.

2.5 PROTECTION OF STARTER AND MOTOR

A. Following protection features shall be provided for starter and motor:
   1. Instantaneous overcurrent protection.
   2. Electronic overload protection.
   3. Adjustable under/over voltage protection.
   4. Line current imbalance protection.
   5. Single phase / phase loss, phase reversal protection
   6. Undercurrent / load loss
   7. Stall and jam protection.
   8. Adjustable starts per hour protection.
   9. Adjustable time between starts
   10. Shorted SCR detection
   11. Starter overtemperature.
   12. Controller fail
   13. Machine ground fault protection
   14. Selectable current limit during motor start

2.6 METERING AND MONITORING

A. Following metering and monitoring shall be provided:
   1. Each phase current
   2. Each phase voltage
   3. Frequency
   4. Thermal overload in percent
   5. Motor power factor
6. Elapsed time meter

2.7 OUTPUT CONTACTS

A. The controller shall be provided with at least four (4) programmable output relays. The relays shall be programmable via the keypad and shall not require any hardware modification.

B. In addition to the above relays, a fixed, latched, form C, general fault output relay shall be provided. This relay shall be activated when the protection setting are reached and shall shutdown the motor.

2.8 BYPASS CONTACTOR

A. Bypass contactors shall be provided and microprocessor based control logic shall control the operation of the bypass contactor via output relays.

B. The shorting contactors shall close, shorting the SCRs after the acceleration ramp is complete and motor current is below the predetermined value, and opens on stop command to slowly allow a deceleration ramp.

C. Overload protection to the starter shall continue to provide the motor protection when SCRs are bypassed.

D. Where specified or shown on the drawings, a complete combination bypass starter with motor overload relays shall be provided.

2.9 WIRING

A. All control wire shall be UL / CSA approved.

B. Standard control wire shall be 14 GA, stranded, tin plated, dual rated XLPE 125 degree C, CIS 90 degree C.

C. Current transformer circuit shall utilize # 12 AWG wires. Provide shorting block for all current transformers.

D. Provide “plug-in” terminal blocks, rated 600 volt, 50 A with clamping collar.

E. “Clamping collar” type terminals shall be used to terminate control wiring. Current transformers shall be provided with ring-type terminals.

F. Wire marker shall be a molded plastic clip sleeve type.

2.10 INSTRUMENT TRANSFORMER

A. CURRENT TRANSFORMER (C T)

Current transformers shall be provided where required.

1. The current transformers shall have ratios, and relay and metering accuracy as required for the each motor starter and the starter.

2. C T shall be multi-ratio, rated to withstand the specified operational, short-circuit, and voltage impulse conditions, and shall conform to ANSI C 57.13.
3. The voltage class shall be not less than that of the motor starter in which they are installed. The C T shall be either of the wound, window, or bar type and shall have five (5) ampere secondary. Window type current transformers for ground sensors shall have adequate opening for power cables of the size indicated on the drawings.

4. The metering and relaying accuracy class of C T shall be per ANSI C 57.13.

5. All current transformers shall have five ampere secondary and shall be wired to short-circuiting type terminals or test blocks located in the secondary termination compartment.

6. When secondary windings of current transformers are required to be grounded they shall be grounded at one point only at the terminal boards or test blocks which shall be readily accessible and clearly identified.

– END OF SECTION –
SECTION 16483 – VARIABLE FREQUENCY DRIVE CONTROLLERS

PART 1 – GENERAL

1.01 WORK INCLUDED

A. This Section includes solid-state, Pulse Width Modulation (PWM), VFDs for speed control of three-phase, induction motors. VFDs are to be integral to motor control centers when applicable. All VFD Controllers shall be equipped with Profibus System Accessory Interface module and Communication Module with input points.

1.02 SUBMITTALS

A. Product Data: For each type of VFD, provide dimensions; mounting arrangements; location for conduit entries; shipping and operating weights; and manufacturer's technical data on features, performance, electrical ratings, characteristics, and finishes.

B. The following shall be included in the Proposal package:

1. Description of equipment and tests included in Proposal to meet the indicated power quality requirements.

2. Nearest factory authorized service center meeting all requirement of 1.3A.

3. Qualification and name of engineering and technical persons responsible for support and warranty of this project.

C. The following shall be included in the submittal package and be approved by the ENGINEER prior to any construction of the VFD system:

1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:

   a. Each installed unit's type and details.

   b. Nameplate legends.

   c. Short-circuit current ratings of integrated unit.

   d. UL listing for series rating of overcurrent protective devices in combination controllers.

   e. Features, characteristics, ratings, and factory settings of each motor controller (VFD).

2. Wiring Diagrams: Power, signal, and control wiring for VFD. Provide schematic wiring diagram for each type of VFD.

4. Carrier frequency information.

D. Qualification Data: For testing agency and manufacturer.

E. Field Test Reports: Written reports specified in Part 1.12 below.

F. Manufacturer's field service report.

G. Operation and Maintenance Data: For VFDs, all installed devices, and components to include in emergency, operation, and maintenance manuals. In addition to items specified in other sections, include the following:

1. Routine maintenance requirements for VFDs and all installed components.

2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

1.03 QUALITY ASSURANCE

A. Manufacturer Qualifications: Maintain, preferably in Visalia, CA, a service center capable of providing training, parts, and 24 hour emergency maintenance and repairs.

B. Source Limitations: Obtain VFDs of a single type through one source from a single manufacturer.

C. The system shall be pre-integrated with the necessary harmonic mitigation equipment.

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


PART 2 – PRODUCTS

2.01 COORDINATION

A. Match features of VFDs, installed units, and accessory devices with pilot devices and control circuits to which they connect.

B. Match features, accessories, and functions of each VFD and each installed unit with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load. See Divisions 15 and 17 sections for information on motor control requirements.

2.02 VARIABLE FREQUENCY CONTROLLERS

A. Description: NEMA ICS 2, IGBT, PWM, VFD; listed and labeled as a complete unit and arranged to provide variable speed of a NEMA MG 1, Design B, 3-phase, induction motor by adjusting output voltage and frequency. Refer to Section 16150 for additional information on motors controlled by VFDs.
B. VFDs will be required for the following:

<table>
<thead>
<tr>
<th>Qty.</th>
<th>Equipment</th>
<th>Constant / Variable Torque</th>
<th>RPM</th>
<th>Enclosure Type</th>
<th>Voltage / Phases</th>
</tr>
</thead>
<tbody>
<tr>
<td>TBD</td>
<td>Blowers</td>
<td>Variable</td>
<td>3600</td>
<td>12</td>
<td>460/3</td>
</tr>
</tbody>
</table>

C. Design and Rating: Match load type such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

D. Output Rating: 3-phase; 6 to 120 Hz, with horsepower constant throughout speed range.

E. Unit Operating Requirements:
   1. Input ac voltage tolerance of 480 V, plus or minus 10 percent.
   2. Input frequency tolerance of 60 Hz, plus or minus 6 percent.
   3. Output Rating: 3-phase; 6 to 66 Hz, with amperage equal or greater to motor nameplate amperage including altitude derating.
   4. Minimum Inverter Efficiency: 96 percent at 60 Hz, full load.
   5. Minimum Displacement Primary-Side Power Factor: 96 percent lagging.
   6. Overload Capability: 1.1 times the base load current for 60 seconds; 2.0 times the base load current for 3 seconds.
   7. Starting Torque: Default to be 50% with adjustment to 120%.
   8. Speed Regulation: Plus or minus 1 percent.
   9. Isolated control interface to allow controller to follow control signal over an 10:1 speed range.

F. Internal Adjustability Capabilities:
   1. Minimum Speed: 5 to 25 percent of maximum rpm.
   2. Maximum Speed: 80 to 100 percent of maximum rpm.
   3. Acceleration: Adjustable from 0.01 to 3600 seconds.
   4. Deceleration: Adjustable from 0.01 to 3600 seconds.
   5. Current Limit: 50 to 110 percent of maximum rating.

G. Self-Protection and Reliability Features:
   1. Input transient protection by means of surge suppressors.
   2. Snubber networks to protect against malfunction due to system voltage transients.
3. Under- and overvoltage trips; inverter overtemperature, overload, and overcurrent trips.

4. Filtering to prevent noise interference with other electronic equipment.


7. Instantaneous line-to-line and line-to-ground overcurrent trips.


10. Short-circuit protection.

11. Motor overtemperature fault.

H. Automatic Reset and Restart: To attempt three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Bi-directional auto speed search shall be capable of starting into rotating loads spinning in either direction and returning motor to set speed in proper direction, without damage to controller, motor, or load.

I. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped. VFD to automatically re-start motor after outage.

J. Carrier Frequency Adjustment: Provide ability to manually adjust drive carrier frequency. VFDs 100HP and less shall provide carrier frequency adjustment capability from 1 to 10 kHz. VFDs over 100HP shall include carrier frequency adjustment information recommended by the manufacturer.

K. Torque Boost: Automatically vary starting and continuous torque to at least 1.5 times the minimum torque to insure high-starting torque and increased torque at slow speeds.

L. Motor Temperature Compensation at Slow Speeds: Adjustable current fallback based on output frequency for temperature protection of self-cooled fan-ventilated motors at slow speeds.

M. Provide line and load side filtering to minimize total harmonic distortion.

N. Status Lights: Door-mounted LED indicators shall indicate the following conditions:

1. Power on.
2. Run.
3. Overvoltage.
4. Line fault.
5. Overcurrent.


P. Indicating Devices: Meters or digital readout devices and selector switch, mounted flush in controller door and connected to indicate the following controller parameters:

1. Output frequency (Hz).
3. Motor status (running, stop, and fault).
5. Motor torque (percent).
6. Fault or alarming status (code).
7. PID feedback signal (percent).
8. DC-link voltage (VDC).
9. Set-point frequency (Hz).
10. Motor output voltage (V).

Q. Control Signal Interface: Provide VFD with the following:

1. Electric Input Signal Interface: A minimum of 2 analog inputs (0 to 10 V or 0/4-20 mA) and 6 programmable digital inputs.
2. Pneumatic Input Signal Interface: 3 to 15 psig (20 to 104 kPa).
3. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the BMS or other control systems:
   a. 0 to 10-V dc.
   b. 0-20 or 4-20 ma.
   c. Potentiometer using up/down digital inputs.
   d. Fixed frequencies using digital inputs.
   e. RS485.
   f. Keypad display for local hand operation.
4. Output Signal Interface:
   a. Provide analog output signals (0/4-20 mA), which can be programmed for the following:
      b. Output frequency (Hz).
      c. Output current (load).
d. DC-link voltage (VDC).
e. Motor torque (percent).
f. Motor speed (rpm).
g. Set-point frequency (Hz).

5. Remote Indication Interface: Provide dry circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
   a. Motor running.
   b. Set-point speed reached.
   c. Fault and warning indication (overtemperature or overcurrent).
   d. PID high or low speed limits reached.

6. Communication link: Profibus

R. Provide bypass switch and contactor to allow manual bypass of the drive and across-the-line starting.

S. Integral Disconnecting Means: Provide Heating, Air Conditioning & Refrigeration (HACR) rated breaker as indicated on drawings.

2.03 ACCESSORIES

A. Devices shall be factory installed in motor control center.


C. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.

D. Control Relays: Auxiliary and adjustable time-delay relays.

E. Standard Displays:
   1. Output frequency (Hz).
   2. Set-point frequency (Hz).
   4. DC-link voltage (VDC).
   5. Motor torque (percent).
   7. Motor output voltage (V).
F. Historical Logging Information and Displays:

1. Real-time clock with current time and date.
2. Running log of total power versus time.
3. Total run time.
4. Fault log, maintaining last four faults with time and date stamp for each.

G. Current-Sensing, Phase-Failure Relays for Bypass Controller: Solid-state sensing circuit with isolated output contacts for hard-wired connection; arranged to operate on phase failure, phase reversal, current unbalance of from 30 to 40 per-cent, or loss of supply voltage; with adjustable response delay.

H. Harmonic Mitigation: Complying with IEEE Standard 519-1992 shall be a requirement of this project. Harmonic filters, 18 pulse converter configurations, phase multiplication devices, or any other components required to mitigate harmonic voltage and current to IEEE Std. 519-1992 shall be an integral part of the VFD system. Designs which are not pre-integrated and factory wired as part of the UL label will not be acceptable.

1. Designs which cause voltage rise at the VFD terminals must document coordination with the total system variation to prevent nuisance tripping.
2. Designs which do not provide both true and displacement, measured at the VFD terminals, of at least 95% or better at full load are not acceptable. Designs that allow leading power factor at minimum loads are not acceptable.

I. Relevant data for VFD EQUIPMENT SUPPLIER calculations to meet IEEE Std. 519-1992 requirements are as follows:

1. The point of common coupling (PCC) shall be defined per IEEE Std. 519-1992.
2. The calculated load current (IL) shall be the total combined full load current of each ASD system supplied as part of this project or the total combined amperage of loads designated as “non-linear”.
3. The short circuit current (ISC) available at the PCC is estimated at 65,000 amps.

2.04 MANUFACTURERS

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

5. Or approved equal

B. Contractor job site integration of reactors, harmonic filters, power components, etc. will not be acceptable. Start-up, harmonic testing and warranty support services must be supplied by the above or other ENGINEER pre-qualified vendor/manufacturer.
PART 3 – EXECUTION

3.01 EXAMINATION

A. Examine areas, surfaces, and substrates to receive VFDs for compliance with requirements, installation tolerances, and other conditions affecting performance.

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

3.02 APPLICATIONS

C. Select features of each VFD to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; and duty cycle of motor, drive, and load.

D. Select rating of controllers to suit motor controlled. The VFD vendor shall certify that the supplied equipment is properly matched to the loads being fed.

E. The drive shall be capable of operating in compliance with IEEE 519-1992, with point of common coupling (PCC) as defined by the standard. Drive manufacturer shall provide harmonic calculations and on-site post installation harmonic testing with certified reports prior to final acceptance of installation. See 1.1 2.A.3.

3.03 IDENTIFICATION

F. Operating Instructions: Frame printed operating instructions for VFDs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFD units.

3.04 CONNECTIONS

G. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.05 FIELD QUALITY CONTROL

H. Prepare for acceptance tests as follows:

6. Test insulation resistance for each VFD element, bus, component, connecting supply, feeder, and control circuit.

7. Test continuity of each circuit.


I. Testing: Perform the following field quality-control testing:

9. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Sections 7.5, 7.6, and 7.16. Certify compliance with test parameters.

10. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
J. Manufacturer’s Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including pretesting and adjusting VFDs.

K. Test Reports: Prepare a written report to record the following:

11. Test procedures used.
12. Test results that comply with requirements.
13. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

3.06 STARTUP SERVICE

L. Delete first paragraph below if factory-authorized service representative is not required.

M. Engage a factory-authorized service representative to perform startup service.

N. Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements in Division 16 Sections.

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

3.07 ADJUSTING

P. Set field-adjustable switches.

3.08 CLEANING

Q. Clean VFDs internally, on completion of installation, according to manufacturer's written instructions. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

3.09 DEMONSTRATION

R. Engage a factory-authorized service representative to train CITY's maintenance personnel to adjust, operate, and maintain VFDs.

– END OF SECTION –
PART 1 – GENERAL

1.01 DESCRIPTION

Requirements of Conditions of the Contract, Division 1, Section 16010 and Section 16100 form a part of this Section.

A. Work Included in This Section.
   1. Testing of all electrical equipment and components.

B. Related Work Included in Other Divisions and Sections.
   1. Basic Electrical Materials and Methods, Section 16100.
   2. Induction Motors, Section 16150.

1.02 REFERENCES

The inspections and tests shall be in accordance with the following applicable codes and standards except as provided otherwise herein.

A. National Electrical Code - NEC (NFPA 70).
B. National Electrical Manufacturer’s Association - NEMA.
C. American Society for Testing and Materials - ASTM.
D. Institute of Electrical and Electronic Engineers - IEEE.
E. National Electrical Testing Association - NETA.
F. American National Standards Institute - ANSI.
G. State and Local Codes and Ordinances.
H. Insulated Cable Engineers Association - ICEA.
I. OSHA Part 1910; Subpart S, 1910.308.
J. National Fire Protection Association - NFPA.

1.03 SUBMITTALS

A. Prior to the Start of Work
   1. Written test procedures by the manufacturer. The CITY shall be provided a copy of the test procedures.
   2. Manufacturer’s Test and Report Forms.
B. Upon completion of testing provide formal Test Report to include the following:

1. Summary of test.
2. Description of equipment tested.
3. Description of test.
4. Test results.
   a. The following is a list of reports and forms that the manufacturer shall use in reporting the results:
      1) Instrument Calibration Test and Data Sheet (2 sheets).
      2) Insulation/Megger Resistance Test Report.
      3) Polarity Index Test Results (for 200 hp or larger motor).
5. Conclusions and recommendations.
6. Appendix, including appropriate completed test forms.
7. List of test equipment used and calibration date.

1.04 SYSTEM DESCRIPTION

A. The inspections and tests shall utilize the following references.
   1. Manufacturer’s instruction manuals applicable to each particular apparatus.
   2. Drawings submitted by manufacturers and vendors.

B. All instruments used to evaluate electrical performance shall meet Specifications for Test Instruments (refer to Part 2 of this Specification).

C. Electrical performance tests shall include the following:
   1. 600 volt feeder cables.
   2. Induction motors.

D. The EQUIPMENT SUPPLIER shall notify the CITY when equipment becomes available for electrical tests. Work shall be coordinated to expedite project scheduling.

E. The EQUIPMENT SUPPLIER shall notify the CITY prior to commencement of any testing.

F. Set points shall be noted on all calibration stickers.

G. Any system material or workmanship, which is found defective on the basis of electrical tests shall be replaced and retested at no additional cost to the CITY.

H. The manufacturer shall maintain a written record of all tests and upon completion of the project, assemble and certify a final test report.
PART 2 – PRODUCTS

2.01 TEST INSTRUMENT TRACEABILITY

A. The manufacturer shall have a calibration program, which maintains applicable test instrumentation within rated accuracy.

B. The accuracy shall be traceable to the National Institute for Standards and Technology in an unbroken chain.

C. Instruments shall be calibrated in accordance with the following frequency schedule:

1. Laboratory instruments - 12 months.
2. Leased specialty equipment - 12 months. (Where accuracy is guaranteed in writing by the lessor.)

D. Dated calibration labels shall be visible on all test equipment.

E. Records must be kept up to date which show date and results of all instruments calibrated or tested.

F. An up-to-date instrument calibration instruction and procedure will be maintained for each test instrument.

PART 3 – EXECUTION

3.01 SAFETY AND PRECAUTIONS

A. Safety practices shall include, but are not limited to, the following requirements:

1. Occupational Safety and Health Act - OSHA.
3. Applicable State and local safety operating procedures.
4. NETA Safety/Accident Prevention Program.

3.02 TABLES

Table 16960.1 – Insulation Resistance Test Voltage

<table>
<thead>
<tr>
<th>Maximum Voltage Rating of Equipment</th>
<th>Minimum Test Voltage, DC</th>
<th>Minimum Insulation Resistance in Mega-ohms</th>
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<tr>
<td>250</td>
<td>500</td>
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</tr>
<tr>
<td>600</td>
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<td>100</td>
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<tr>
<td>5,000</td>
<td>2,500</td>
<td>1,000</td>
</tr>
<tr>
<td>Maximum Voltage Rating of Equipment</td>
<td>Minimum Test Voltage, DC</td>
<td>Minimum Insulation Resistance in Mega-ohms</td>
</tr>
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<td>--------------------------</td>
<td>--------------------------------------------</td>
</tr>
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<tr>
<td>15,000</td>
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<td>5,000</td>
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</table>

Values of insulation resistance less than manufacturer’s minimum or kV + 1 in megohms should be investigated. Overpotential tests should not proceed until insulation resistance levels are raised to said minimum.

Table 16960.2 – Insulation Resistance Conversion Factors for Conversion of Test Temperature to 20°C

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Transformer</th>
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<tbody>
<tr>
<td>°C</td>
<td>°F</td>
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<tr>
<td>0</td>
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– END OF SECTION –