

DIVISION 6 - WOOD AND PLASTIC

SECTION 06600

FIBERGLASS REINFORCED POLYMER (FRP) PRODUCTS AND FABRICATIONS

PART 1 GENERAL

1.01 SUMMARY:

A. This section includes the following FRP Products & Fabrications:

1. FRP Pultruded Gratings and Treads
2. FRP Structural Shapes and Plate
3. FRP Standard Railings
4. Molded Gratings and Treads

1.02 SCOPE OF WORK:

A. Furnish all labor, materials, equipment and incidentals governed by this section necessary to install the fiberglass reinforced polymer (FRP) products as specified in the contract documents.

1.03 QUALITY ASSURANCE:

A. The material covered by these specifications shall be furnished by an ISO-9001:2008 certified manufacturer of proven ability who is regularly engaged in the manufacture, fabrication and installation of FRP systems.

1.04 DESIGN CRITERIA:

- A. Uniform design loads for FRP gratings, floor panels and supporting structural members shall be 100 psf at access platforms and 300 psf at operating and containment floors unless specifically stated otherwise in drawings. Grating and floor panel deflection at the center of a simple span not to exceed 0.25".
- B. Structural members shall be sized to support all applied loads. Deflection in any direction shall not be more than L/180 of span for structural members unless specifically stated otherwise in drawings and/or supplementary conditions. Connections shall be designed to transfer the loads.
- C. Temperature exposure is limited to 100°F unless specifically stated otherwise in drawings and/or supplementary conditions.

1.05 SUBMITTALS:

A. Shop drawings of all fabricated pultruded gratings and treads, structural shapes and plate, standard railings, molded gratings and treads and appurtenances shall be submitted to the County for approval. Fabrication shall not start until receipt of County's approval. Final shop drawings and structural calculations shall be signed and sealed by a Professional Engineer registered in the State of Florida.

- B. Manufacturer's catalog data showing:
 - 1. Materials of construction
 - 2. Dimensions, spacings, and construction of grating, handrails and building panels.
- C. Detail shop drawings showing:
 - 1. Dimensions
 - 2. Sectional assembly
 - 3. Location and identification mark
 - 4. Size and type of supporting frames required

PART 2 PRODUCTS

2.01 GENERAL

- A. Materials used in the manufacture of the FRP products shall be raw materials in conformance with the specification and certified as meeting the manufacturer's approved list of raw materials.
- B. The visual quality of the pultruded shapes shall conform to ASTM D4385.
- C. With the exception of molded gratings and treads, all FRP products noted shall be manufactured using a pultruded process utilizing vinyl ester resin with flame retardant and ultraviolet (UV) inhibitor additives. A synthetic surface veil fabric shall encase the glass reinforcement. FRP shapes shall achieve a flame spread rating of 25 or less in accordance with ASTM test method E-84, the flammability characteristics of UL 94 V0 and the self-extinguishing requirements of ASTM D635. (Polyester resin is available without flame retardant and UV inhibitor additives.)
- D. All cut ends, holes and abrasions of FRP shapes shall be sealed with a compatible resin coating.
- E. Should additional ultraviolet protection be required, a one mil minimum UV coating can be applied.
- F. All exposed surfaces shall be smooth and true to form, consistent with ASTM D4385.

PULTRUDED GRATINGS AND TREADS:

- A. General
 - 1. Grating shall be DURADEK® or DURAGRID® as manufactured by Strongwell or approved equal.

B. Design

1. The panels shall sustain a deflection of no more than 0.25" under a uniform distributed load of 100 PSF for the span lengths shown on the plans. See Strongwell's Fiberglass Grating brochure for a list of available sizes.
2. Stair treads shall be capable of withstanding a uniform load of 100 PSF or a concentrated load of 300 lbs. on an area of 4 sq. inches located in the center of the tread, whichever produces greater stress and deflect less than 0.25".
3. The top surface of all panels, gratings, and treads shall have a non-skid grit affixed to the surface by an epoxy resin followed by a top coat of epoxy resin.
4. Hold down clamps shall be type 316L stainless steel clips. Use 2 at each support with a minimum of 4 per panel.
5. Color shall be high visibility yellow or grey.
6. All shapes and fabrications that are to be exposed to UV shall be coated with polyurethane coating of a minimum thickness of 1 mil.

C. Products

1. The FRP grating and stair treads shall be fabricated from bearing bars and cross rods manufactured by the pultrusion process. The glass fiber reinforcement for the bearing bars shall be a core of continuous glass strand rovings wrapped with continuous strand glass mat. A synthetic surface veil fabric shall encase the glass reinforcement.

D. Fabrication of Standard Railing System

1. The fiberglass standard railing system shall be fabricated into finished sections by fabricating and joining together the pultruded square tube using molded or pultruded components; epoxy bonded and connected as shown in the fabrication details. Railing sections shall be fabricated to the size shown on the approved fabrication drawings and shall be piece marked with a water proof tag.

E. For Side Mount

1. Post shall be constructed with a pultruded bottom plug. Length shall be sufficient to extend a minimum of 1" beyond the uppermost bolt hole to prevent crushing of post tubing. Bolt holes shall provide clearance of 1/16" for 1/2" diameter bolts/studs. On square tubes, holes shall be on longitudinal center line of post, 1" from bottom of post (minimum) and not less than 3" apart on center. Posts shall be fastened with stainless steel anchor bolts or studs, 1/2" diameter.
2. Post locations shall be no greater than 18", nor less than 9" from horizontal or vertical change in handrail direction. For square tubes, post centers shall be no greater than 72" apart on any straight run or rail, or 48" apart on any inclined rail section.

F. Other Attachment Methods

1. Base mount, embedded and removable are also types of mounting procedures for railing. Design and calculations must be signed and sealed by a licensed Structural Engineer in the State of Florida and submitted to the County for approval.

G. Installation of Handrail Sections

1. The fabricated railing sections shall be supplied complete with fittings by the FRP manufacturer. The components used to join fabricated sections together may be shipped loose, to be epoxied and riveted, if required, together, if required in the field by the contractor.
2. The fabricated handrail sections shall be installed as shown on the approved shop drawings. The handrail sections shall be accurately located, erected plumb and level. The sections shall be fastened to the structure as shown on the approved shop drawings.

H. Approved Fabricators

1. Strongwell or approved equal.

2.02 MOLDED GRATING AND TREADS

A. General

1. Grating shall be DURAGRATE® as supplied by Strongwell or approved equal.

B. Design

1. The grating shall be one piece construction with the tops of the bearing bars and cross bars in the same plane.
2. The mesh pattern and thickness shall be: (selected pattern and thickness shown on the drawings)
 - a. 3/4" square mesh, 1-1/2" thick
 - b. 1-1/2" square mesh, 1" thick
 - c. 1-1/2" square mesh, 1-1/2" thick
 - d. 2" square mesh, 2" thick
 - e. 1" x 4" rectangular mesh, 1" thick
 - f. 1-1/2" x 6" rectangular mesh, 1-1/2" thick
3. The standard resin systems and colors are: vinyl ester (high visibility yellow or grey).

C. Products

1. The FRP molded grating and treads shall be manufactured by the open mold process.
2. Molded stair treads shall be 1-1/2" thick in a 1-1/2" x 6" rectangular mesh pattern. The resin system will be the same as the molded grating. The stair tread shall come complete with anti-slip nosing.
3. Hold down clamps shall be:
 - a. Type M clips for attaching grating to supports
 - b. Type J clips for attaching grating to supports for moderate loads
4. Grating with cover plate
 - a. Grating shall be the same as described above in this section.
5. The cover plate for molded grating shall be an integrally molded plate as manufactured by Strongwell or approved equal.
 - a. The integrally molded plate may use the same resin as the grating.
 - b. The integrally molded plate shall be bonded to the grating, and a non-skid grit shall be affixed to the top surface of the assembly.

PART 3 EXECUTION

3.01 INSTALLATION, GENERAL

- A. Fastening to in-place construction: Provide anchorage devices and fasteners where necessary for securing miscellaneous FRP fabrications to in-place construction; include threaded fasteners for concrete and masonry inserts, toggle bolts, through-bolts, lag bolts and other connectors.
- B. Cutting, fitting and placement: Perform cutting, drilling and fitting required for installation of miscellaneous FRP fabrications. Set FRP fabrication accurately in location, alignment and elevation; with edges and surfaces level, plumb, true and free of rack; measured from established lines and levels.
- C. Provide temporary bracing or anchors in form work for items that are to be built into concrete masonry or similar construction.

END OF SECTION

SECTION 16370 VARIABLE FREQUENCY DRIVES

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. Work Included in this Section: The CONTRACTOR shall provide all the required labor, project equipment and materials, tools, construction equipment, safety equipment, transportation, and test equipment for furnishing, installation, adjustment, and full test loading of all the electrical work shown on the Drawings and included in these Specifications.
- B. This equipment is to be installed in a prefabricated electrical building by the by CONTRACTOR. Coordinate equipment installation with VFD and building provider.
- C. Variable Frequency Drives and enclosures shall be floor mounted in standalone enclosures provided by VFD manufacturer with all appurtenances included. Enclosure to be NEMA 1 gasketed. No third-party assemblies accepted.
- D. Variable frequency drives shall be 480V, 3-phase, 60Hz, 6-pulse drives with 5% input line reactors, to operate at these locations, with these horsepower's. Each station shall have three pumps each.

LS 1M - 200Hp @ 220 amps (Nameplate Data) - Existing Flygt Pumps
LS 12A - 150Hp - New Flygt Pumps - Coordinate with Specification 11310
LS 13A - 250Hp @ 284 amps (Nameplate Data) - Existing Flygt Pumps

- E. MANUFACTURER to coordinate with pump supplier for incorporating all pump controls and pump protection. Refer to Specification 11310 for more information. CONTRACTOR to oversee and be responsible for such coordination.
- F. Drive Manufacturer shall be Fuji Electric Corp FRENIC-Mega per County request with no equal.

1.02 DRIVE APPLICATION

- A. The variable frequency drives will be used to control the speed of NEMA B design induction motors for dry submersible centrifugal pump in wastewater pumping station. Refer to pump specification 11310 for more information.

1.03 DRIVE PARAMETERS

- A. The variable frequency drives shall be designed and sized for the loads intended, shall not exceed their full-rated capacity when the driven pumps are operating at maximum capacity, shall not overload under any operating condition of the pumps, and shall be provided with an integral bypass motor starter package.

1.04 SPARE PARTS

- A. As a minimum, each of the variable frequency drives shall be furnished with the

following spare parts:

1. One (1) circuit board of each type used.
2. Three (3) spare bulbs of each type and size used.
3. Three (3) lens caps of each color and size used.
4. Three (3) sets of power fuses and circuit breakers.
5. Three (3) sets of control fuses.
6. One (1) enclosure cooling fan.

1.05 MANUFACTURER'S QUALIFICATIONS

- A. The variable frequency drives shall be the products of a single manufacturer who has been in the business of designing and manufacturing variable frequency drives for a period of at least ten (10) years.
- B. The manufacturer shall have a factory authorized representative (s) and/or a certified repair shop(s) staffed with factory trained service personnel capable of providing installation and start-up assistance, routine and 24-hour emergency repair services (including parts), and training for the County's personnel in operating and maintenance procedures associated with the specific variable frequency drives furnished.
- C. The manufacturer shall offer both standard and extended period service contracts as part of his normal operating policy.

1.06 MANUFACTURER'S REPRESENTATIVE

- A. A factory trained authorized representative(s) of the manufacturer shall be available to perform the following functions:
 1. Provide installation assistance to the County's personnel on an "as needed" basis, one (1) scheduled day minimum.
 2. Provide checkout and start-up services as well as conduct the final acceptance tests, two (2) scheduled days.
 3. Provide training for the County's personnel in the proper operation and maintenance techniques to be used with the specific VFD's furnished, two (2) scheduled days.
- B. The manufacturer shall include in his bid sufficient funds to cover all the costs (travel, meals, lodging) associated with providing the services listed in Item 1.06.A.1, 2 and 3 above.

1.07 SUBMITTALS

- A. Within three (3) weeks of receiving the order, the manufacturer shall furnish the County with certified dimension prints which clearly show the nameplate data and outline dimensions.
- B. Prior to start of manufacture of the variable frequency drives, the manufacturer shall submit sets of drawings which shall include, but not necessarily be limited to, enclosure drawings showing the location of both internally and externally mounted components, master wiring diagrams showing all interconnections to the discrete

component level, elementary or control schematics including coordination with other external control devices operating in conjunction with the variable frequency drives, and outline drawings with sufficient details to allow for locating conduit stub-ups and field wiring.

- C. Failure to comply with Item 1.07.B above shall be entirely at the manufacturer's risk. Any changes required as a result of the County's review will be solely at the manufacturer's expense with no cost to the County.

1.08 WARRANTY

- A. The manufacturer shall warrant that the variable frequency drives shall be free from defects in all materials and workmanship for a period of two (2) years from date of final acceptance.
- B. During the Warranty period, any and all covered defects shall be corrected by the manufacturer solely at his own expense with no cost to the County.

PART 2 PRODUCTS

2.01 VARIABLE FREQUENCY DRIVES

A. GENERAL

1. The variable frequency drives shall be the adjustable frequency (AF), variable torque (VT), pulse width modulated (PWM) type designed to provide continuous speed adjustment of 3-phase NEMA B squirrel cage induction motors, inverter duty rated.
2. The adjustable frequency drives (VFD's) shall be designed and rated for the horsepower (HP) and at full-load current (Amps), at rated speed (RPM) of the motors actually supplied.
3. The VFD's shall be furnished in NEMA Type 1 gasketed floor-mounted enclosures. The enclosures shall be forced air ventilated using door-mounted fans. Fan installation shall include cleanable, reusable air filters.
4. IEC Reduced Voltage Bypass Starter for emergency operation or for VFD Maintenance.

B. CONSTRUCTION

1. The VFD's shall be microprocessor based solid state devices consisting of three (3) basic sections:
 - a. A rectifier section to change the constant frequency AC input voltage to a DC voltage. A full wave rectifier shall be used to prevent input line notching. Internal fast acting semiconductor fuses shall be installed to preclude the necessity for having external AC line fuses.
 - b. A DC bus/link section to interconnect the rectifier section and the inverter section. A DC line reactor and capacitors shall be used to smooth the DC bus/link operation, improve displacement power factor, lower harmonic distortion, and eliminate the need for an isolation transformer.
 - c. An inverter section to convert the DC voltage to a variable frequency

AC voltage. Insulated gate bipolar transistors (IGBT's) shall be used as output switching devices to allow "trip-less" operation, reduce motor noise, provide smoother motor operation, assure reliable and safe shutdowns under fault conditions, and increase drive efficiency; specifically, SCR's, GTO's, and Darlingtion Transistors are not acceptable as switching devices under this Specification.

2. The VFD's shall be capable of operating from a 3-phase input voltage of 480 Volts $\pm 10\%$ over a frequency range of 0-63 Hertz while providing a constant volts per Hertz excitation to the motors.
3. The VFD's shall have a one minute overload rating of 150%, minimum.
4. The VFD's shall employ surface mount technology for reduced size, high reliability, ease of maintenance, and resistance to vibration.
5. The VFD's shall incorporate full internal protection against short circuits, ground faults, over- and under voltage, over- and undercurrent, and temperature extremes.
6. The VFD's shall contain an adjustable electronic motor overload (I^2t) circuit to eliminate the need for an external motor overload relay.
7. The VFD's shall utilize advanced diagnostic techniques to simplify trouble shooting and correcting problems.
8. The VFD's shall have a minimum drive efficiency of 97% at full speed and full load.
9. The VFD's shall have a minimum fundamental power factor of 0.98 at all speeds and loads.
10. The VFD's shall be able to operate under the following environmental conditions without modification or derating:
 - a. Temperature: 0 to 40°C.
 - b. Altitude: Up to 3,300' above sea level.
 - c. Humidity: 0 to 95%, non-condensing.
11. The VFD's shall be UL listed and shall comply fully with the applicable standards and provisions of ANSI, NEMA, IEEE, IEC, and NEC, latest revisions.

C. FEATURES

1. The VFD's shall, as a minimum, have the standard features and adjustments listed below:
 - a. The VFD's shall have the same customer interface regardless of horsepower rating, including keypad, digital display, and user connections. The keypad and the digital display shall be accessible without opening the main door of the drive enclosures.
 - b. Hand-Off-Auto door mounted function switch. In Hand, local control via potentiometers In Auto, remote control via existing Data Flow Telemetry device.
 - c. Door mounted By-Pass switch to engage bypass soft start and isolate VFD.
 - d. The keypad shall be the seven (7) button touch type and shall be used for start-up, for setting all parameters, for stepping through the

- displays and menus, and for local control, including speed adjustments.
- e. In addition to the keypad speeds adjustment provisions, the VFD's shall also be furnished with a manual speed adjustment potentiometer. The potentiometer shall be accessible without opening the main door of the drive enclosures.
 - f. The digital display shall be the LCD alphanumeric type with 40-character, 2-line capability. The LCD display shall be backlit to provide easy viewing at any angle in any light condition. The display shall have adjustable contrast.
 - g. The display shall utilize plain English - i.e., all set-up parameters, indications, faults, warnings, and other such information must be displayed in words for easy user understanding; specifically, alphanumeric code numbers requiring memorization, cross-reference tables, or manuals for interpretation will not be acceptable under this Specification.
 - h. The VFD's shall incorporate pre-programmed application macros for ease of start-up. To reduce programming time, the macros shall provide one command operation to reprogram all parameters and user interfaces for a particular application.
 - i. The VFD's shall provide a user selectable option of either displaying a fault or running at a preset speed if a reference input is lost.
 - j. The VFD's shall be capable of a "flying start" into a rotating load and accelerating to set-point without safety tripping or damage to the drives or driven equipment.
 - k. The user terminal strip shall be isolated from both the line and ground.
 - l. The VFD's shall have the ability to automatically restart after an overcurrent, overvoltage, under voltage, or loss of input signal protective trip. The number of restart attempts, trial time, and time between reset attempts shall be programmable. If the time between reset attempts is greater than zero, the time remaining until reset occurs shall count down on the display to warn an operator that a restart will occur.
 - m. The VFD's shall be equipped with an automatic extended power loss ride-through circuit which will utilize the inertia of the load to keep the drive powered. Minimum power loss ride-through shall be one-cycle, based on full load and no inertia. Removing power from the motor will not be an acceptable method of increasing power loss ride-through under this Specification.
 - n. The VFD's shall be optimized for a 3 kHz carrier frequency to reduce motor noise.
 - o. The VFD's shall incorporate the following three (3) separate current limit circuits to provide "trip free" operation:
 - 1) A slow current regulation limit circuit which shall be an adjustable percentage of the VFD's variable torque current rating, minimum setting of 125%. This adjustment shall be made via the keypad and shall be displayed in actual amperes, not as a percentage of full load.
 - 2) A rapid current regulation limit circuit which shall be an adjustable percentage of the VFD's variable torque current rating, minimum setting of 170%.

- 3) A current switch-off limit circuit which shall be a fixed percentage of the VFD's variable torque current rating, minimum setting of 255% instantaneous.
- n. In addition to any items listed above, the VFD's shall, as a minimum, contain the following built-in software features:
- 1) Automatic slip-compensation for maintaining motor speed under varying load conditions.
 - 2) A motor under-load function to protect the pumps.
 - 3) Starting torque up to 180% of full load torque.
 - 4) User selectable manual or automatic IR compensation for torque increases over a selected frequency range.
 - 5) Five (5) adjustable/selectable critical frequency lock-out bands to avoid load resonance points during ramp-up or ramp-down.
 - 6) Two (2) acceleration and two (2) deceleration ramps, adjustable from 0.1 seconds to 1800 seconds.
 - 7) Three (3) adjustable S-curve acceleration and deceleration patterns.
 - 8) User selectable linear, squared, or automatic control of the Volts-per-Hertz shape to assure maximum energy efficiency.
 - 9) Precise full range frequency resolution adjustable in 0.01 Hertz increments.
 - 10) Integral kilowatt-hour and elapsed-time displays.
 - 11) Integral PI and sequential control functions.
 - 12) Hand-Off-Auto function switch. In Hand, local control via pushbuttons and potentiometer in addition to the integral keypad. In Auto remote control via existing Data Flow Telemetry device.
- o. The VFD's shall have seven (7) programmable preset speeds as well as unidirectional rotation and coast-to-a-stop features.
- p. The VFD's shall have two (2) programmable analog inputs capable of accepting either a current or a voltage signal. Inputs shall be filtered and shall have adjustable gain and offset.
- q. The VFD's shall have six (6) programmable digital inputs.
- r. The VFD's shall have two (2) programmable analog outputs proportional to the chosen reference (frequency, motor speed, etc.).
- s. The VFD's shall have three (3) programmable digital outputs. Outputs must be true Form C relays; specifically, open collector outputs will not be acceptable under this Specification.
- t. The VFD's shall be equipped with an ethernet port capable of communicating with external PLC's, DCS's, DDC's, and touch-screen graphic operator panels via Modbus TCP/IP.
- u. The VFD's digital display shall contain, as a minimum, the following information shown in complete English words; specifically, alphanumeric code numbers requiring memorization, cross-reference tables, or manuals for interpretation will not be acceptable under this Specification:

Output Frequency	DC Bus Voltage
Output Voltage	Heat sink Temperature
Motor Speed	Analog Input Values
Motor Current	Keypad Reference Values
Calculated Motor Torque	Elapsed Time
Calculated Motor Power	Kilowatt-hours

v. The VFD's shall, as a minimum, incorporate the following protective circuits which, in the case of a protective trip, shall stop the drive and announce the fault condition in complete English words; specifically, alphanumeric code numbers requiring memorization, cross-reference tables, or manuals for interpretation will not be acceptable under this Specification:

- 1) Overcurrent: Trip set at 315% instantaneous (225% RMS) of the VFD's variable torque current rating.
- 2) Overvoltage: Trip set at 130% of the VFD's rated voltage.
- 3) Under voltage: Trip set at 65% of the VFD's rated voltage.
- 4) Over temperature: Trip set at +70°C or +85°C dependent upon drive furnished.
- 5) Ground Fault: Both "running" and "at start".
- 6) Adaptable Electrical Motor Overload (I^2t): Motor protection shall be based on motor speed and load; specifically, circuits which are not speed dependent will not be acceptable under this Specification.
- 7) RTD analog input motor winding and pump bearing protection module with thermal bias. Provide Solcon model TPR6-14-2-M with a Modbus RTU to Ethernet/IP conversion gateway, or as otherwise shown on contract drawings.

w. The VFD's shall incorporate a parameter lock feature which will prevent unauthorized personnel from altering the drive parameters without entering a programmable password or combination number. The parameter lock shall also be settable to a digital input.

D. FACTORY INSTALLED OPTIONS

1. In addition to the Hand-Off-Auto switch and speed potentiometer mentioned hereinabove, the VFD's shall include the following factory installed options:
 - a. IEC Reduced Voltage Bypass Starter for emergency operation or VFD Maintenance. This Bypass system shall be able to effectively isolate the VFD for removal.
 - b. Circuit Breaker: The circuit breaker shall be the thermal magnetic, thru-the-door interlock type, pad lockable in the Off position.
 - c. 115 VAC Control Transformer and Terminal Board: A terminal board shall be provided for convenient connection of all field control wiring, including all drive inputs and outputs and 115 VAC start input. A control transformer, 150 VA minimum, shall also be included.
 - d. Numbered Wires: All internal drive wires shall be numbered at both

- e. ends to facilitate maintenance and trouble shooting.
LED Push-to Test pilot lights for "RUN" (red), "OFF" (green), "VFD FAULT" (amber) and "Control Power ON" (white), "In Bypass" (Blue).

E. MANUFACTURERS:

- a. Manufactured by Fuji Electric.
- b. No approved equal.

PART 3 EXECUTION

3.01 FACTORY TESTING

- A. Prior to assembly in the VFD's, all printed circuit boards shall be thoroughly factory tested and given a minimum eight (8) hour burn-in.
- B. After assembly, the drives shall be given a minimum eight (8) hour load test using a driven motor. The load shall be continuously cycled from no-load to full rated load to induce maximum stress and thermal variations in the drive components.
- C. During the load test, the major drive parameters (input volts, output volts, output current, output speed, output frequency, percent load, etc.) shall be recorded and a copy of the test results shall be reviewed by the County prior to the shipment of the VFD's. Similarly, any failure(s) of the drives during the load test shall be recorded, analyzed, corrected, and reported to the County before shipment of the VFD's.

3.02 SHIPPING

- A. The VFD's shall be so packaged for shipment that they are maximally protected from both physical and environmental damage.
- B. The VFD's shall be transported to the County's job sites utilizing the manufacturer's customary method of shipment.

3.03 INSTALLATION

- A. The VFD's shall be installed by the CONTRACTOR personnel in accordance with the recommendations and procedures set forth in the installation manual furnished by the manufacturer.

3.04 CHECKOUT AND START-UP

- A. Prior to start-up, a factory trained representative(s) of the manufacturer shall be on hand to assure that the VFD's have been properly installed and that all field wiring is correctly terminated.
- B. After checkout, the manufacturer's representative(s) shall then conduct a certified factory start-up using procedures and forms established by the manufacturer of the VFD's.
- C. A copy of the certified start-up form(s) for each drive shall be provided to the County, and a copy shall be kept on file by the manufacturer.

3.05 FIELD TESTING

- A. After satisfactory completion of the checkout and start-up procedures, the manufacturer's representative(s) shall begin an eight (8) hour acceptance test using actual plant loads.
- B. Any and all short-comings discovered and/or failures occurring during the acceptance test shall be remedied by the manufacturer solely at his own expense with no cost to the County.
- C. Any time after four (4) hours of acceptance testing, the County may, at his option, curtail further testing and take acceptance of the VFD's.

3.06 TRAINING

- A. As set forth in Items 1.05.B and 1.06.A above, a factory trained authorized representative(s) of the manufacturer shall be available at such a time(s) and place(s) established by the owner to train the County's personnel in the proper operation and maintenance procedures required by the specific VFD's furnished.

3.07 WARRANTY

- A. The manufacturer shall furnish to the County a written warranty which complies with the requirements set forth in Item 1.08 above.

END OF SECTION

SECTION 16423 MOTOR CONTROL CENTERS

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:

1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown, specified, and required to furnish and install motor control centers. This equipment is to be installed in a prefabricated electrical building by CONTRACTOR. Coordinate equipment installation with MCC and building provider.
2. Wiring shall conform to Section 16120, Wires and Cables.

B. The CONTRACTOR shall provide the coordination:

1. To properly size circuit breakers, starters, and control power transformers, obtain motor nameplate data on equipment being furnished under this and other contracts as required.
2. To properly size control power transformers, obtain data on motor space heater and other accessories.
3. Review installation procedures under this and other Sections and coordinate installation of items to be installed with or before motor control center Work.

C. Related Sections:

1. Section 16075, Identification for Electrical Systems.
2. Section 16120, Wires and Cables
3. Section 16289, Surge Protective Devices

1.02 REFERENCES

A. Standards referenced in this Section are:

1. ANSI/IEEE C37.2, Electrical Power System Device Function Numbers and Contact Designations.
2. ANSI/NETA ATS, Acceptance Testing Specifications for Electrical Power Equipment and Systems.
3. NEMA ICS 18, Motor Control Centers.
4. NEMA ICS 1, Industrial Controls and Systems: General Requirements.
5. UL 845, Motor Control Centers.

1.03 QUALITY ASSURANCE

A. Qualifications:

1. Manufacturer: Shall have not less than twenty years' experience in the United States of producing equipment substantially similar to that required

and shall be able to submit documentation of not less than five installations in satisfactory operation for at least five years each.

2. Independent Field Testing Firm:

- a. Retain an independent testing firm to perform field acceptance testing of motor control centers.
- b. Testing firm and its assigned personnel shall be experienced in inspecting and testing motor control centers.
- c. Testing firm shall be a member company of NETA.

B. Component Supply and Compatibility:

1. Obtain materials and equipment included in this Section, regardless of component manufacturer, from one motor control center equipment manufacturer.
2. Motor control center equipment manufacturer shall review and approve, or shall prepare, all Shop Drawings and other submittals for components furnished under this Section.
3. Equipment shall be specifically constructed for specified service conditions. Equipment and components shall be integrated into overall motor control center equipment system by motor control center equipment manufacturer.

C. Regulatory Requirements: Comply with the following:

1. NEC Article 430, Motors, Motor Circuits, and Controllers.

1.04 SUBMITTALS

A. Shop drawings and product data as described in Division 1.

B. Operation and maintenance data as described in Division 1.

C. In addition, submit the following:

D. Action Submittals: Submit the following:

1. Shop Drawings:

- a. Outline and summary sheets with schedules of equipment in each unit.
- b. One-line diagrams indicating circuit breaker sizes, bus rating, motor controller ratings, and other pertinent information to demonstrate compliance with the Contract Documents.
- c. Unit control schematic and elementary wiring diagrams showing numbered terminal points and interconnections to other units.

2. Product Data:

- a. Manufacturer specifications, cut sheets, dimensions, and technical

data for all components, materials, and equipment proposed for use.

3. Testing Plans, Procedures, and Testing Limitations:
 - a. Not less than 30 days prior to actual factory testing, submit proposed testing methods, procedures, and apparatus.
 - b. Not less than 30 days prior to actual field testing, submit proposed testing methods, procedures, and apparatus.

E. Informational Submittals: Submit the following:

1. Supplier Instructions:
 - a. Instructions for shipping, storing and protecting, and handling the materials and equipment.
 - b. Installation data for the equipment, including setting drawings, templates, and directions and tolerances for installing anchorage devices.
 - c. Instructions for start-up and troubleshooting.
2. Source Quality Control Submittals:
 - a. Reports of completed factory testing, including procedures used and test results.
3. Site Quality Control Submittals:
 - a. Reports of completed field testing, including procedures used and test results.
4. Supplier Reports:
 - a. Submit written report of results of each visit to Site by Supplier's service technician, including purpose and time of visit, tasks performed, and results obtained. Submit within two days of completion of visit to the Site.
5. Qualifications Statements:
 - a. Independent testing firm.
 - b. Manufacturer, when requested by ENGINEER.

F. Closeout Submittals: Submit the following:

1. Operations and Maintenance Data:
 - a. Submit complete installation, operation and maintenance manuals including test reports, maintenance data and schedules, description of operation, and spare parts information.
 - b. Manuals shall include record drawings of control schematics, including point-to-point wiring diagrams.

c. Comply with Section 01730, Operating and Maintenance Data.

G. Maintenance Material Submittals: Furnish the following:

1. Spare Parts:

a. Furnish, tag, and box for shipment and long-term storage the following spare parts and special tools for each motor control center lineup furnished:

Item	Quantity per Switchgear Lineup Furnished
1) Starters and feeder breakers	Quantities and sizes as shown on drawings
2) Fuses	Six of each type and size used
3) Auxiliary control relays	Two, with at least two normally open and two normally closed contacts
4) Control power transformers	Two of each size used
5) Indicating lamps	Twelve
6) Covers for indicating lamps	Six of each color used
7) Starters: Contact kits for Size 1 motor starter	Two sets
8) Starters: Contact kits for Size 2, Size 3, and Size 4 motor starters	One set of each size

b. Furnish a list of additional recommended spare parts for an operating period of one year. Describe each part, the quantity recommended and current unit price.

1.05 DELIVERY, STORAGE AND HANDLING

A. Packing, Shipping, Handling, and Unloading:

1. Packing:

- a. Inspect prior to packing to assure that assemblies and components are complete and undamaged.
- b. Protect mating connections.
- c. Indoor containers shall be bolted to skids. Breakers and accessories shall be packaged and shipped separately.
- d. Cover all openings into enclosures with-vapor inhibiting, water-repellent material.

2. Upon delivery, check materials and equipment for evidence of water that may have entered equipment during transit.

3. Handling:

- a. Lift, roll or jack motor control center equipment into locations shown.

- b. Motor control centers shall be equipped to be handled by crane. Where cranes are not available equipment shall be suitable for placement on rollers using jacks to raise and lower the groups.

B. Storage and Protection:

- 1. Store motor control center equipment in a clean, dry location with controls for uniform temperature and humidity. Protect equipment with coverings and maintain environmental controls.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Provide equipment by one of the following:

- 1. Schneider Electric/Square D Company.
- 2. No equal.

2.02 MATERIALS

A. General: Motor control center lineups shall comply with NEMA ICS 18 and be provided as shown with the following ratings:

- 1. Service: Voltage rating and number of wires shall be as shown or indicated on the Drawings. Motor control center shall operate from a three-phase, 60 Hertz system.
- 2. Wiring: NEMA Class II, Type B.
- 3. Enclosure: NEMA 1 with gaskets on all doors.
- 4. Interrupting Capacity Rating: Motor control center shall have an interrupting capacity rating as shown or indicated on the Drawings. Devices shall be suitable for minimum rating indicated.
- 5. Motor control center lineups shall be UL-rated as suitable for service entrance where shown or indicated on the Drawings and as required.

B. Construction: Provide equipment with the following:

- 1. Totally-enclosed structure, dead front, consisting of nominal 20-inch deep, 20-inch wide, 7.5-foot high vertical sections bolted together to form a unit assembly.
- 2. Vertical sections shall have side sheets extending the full height and depth of section.
- 3. Removable lifting angles for each shipping section.
- 4. Two removable floor sills for mounting.
- 5. Horizontal wireways top and bottom, isolated from horizontal bus and readily accessible.
 - a. Wireway openings between sections shall have rounded corners and rolled edges.
- 6. Isolated vertical wireways with cable supports, accessible through hinged doors, for each vertical section.

- a. Wireway shall be separate from each compartment and remain intact when compartment is removed.
 7. All-metal non-conducting parts electrically continuous.
 8. Comply with NEMA ICS 18.
- C. Bus System:
1. Rating: Bus bracing and bus current capacities as shown or indicated on the Drawings.
 2. Bus bars shall be tin-plated, copper-rated, and comply with UL heat rise standards.
 3. Bus bar connections shall be easily accessible with simple tools.
 4. Main Horizontal Bus:
 - a. Continuous, edge-mounted, and isolated from wireways and working areas.
 - b. Mount the bus in vertical center of motor control center to provide easy access and even heat distribution.
 - c. Bus shall be supported, braced, and isolated by high-strength, non-tracking, FRP material.
 5. Vertical Bus:
 - a. Continuous, and isolated by glass polyester barrier.
 - b. Rated for 300 amperes continuous minimum, and at least equal to full-load rating of all installed units in the associated stack.
 6. Grounding Bus: Full length mounted across the bottom, drilled with lugs of appropriate capacity as required.
 7. Neutral Bus: Insulated, continuous through control center for four-wire services, drilled with lugs of appropriate capacity as required.
- D. Unit Compartments:
1. Provide individual front door for each unit compartment. Fasten door to stationary structure, instead of the unit itself, so that door can be closed when unit is removed.
 2. Starter and feeder unit doors interlocked mechanically with unit disconnect device to prevent unintentional opening of door while energized and unintentional application of power while door is open, with provisions for releasing interlock for intentional access and application of power.
 3. Padlocking arrangement permitting locking disconnect device in the "OFF" position with at least three padlocks with door closed or open. Equip unit disconnect devices located in the top compartment, compartment sized 12 inches or higher, with extender handle complying with UL 845. Extender handle shall allow disconnect operating handle to be located above NEC's height limitation of six-feet, seven-inches above floor.
 4. Equip compartments as shown or indicated on the Drawings:

- a. Blank compartments, unused space, and compartments shown or indicated on the Drawings as "SPACE" shall have bus covers and be complete with necessary hardware for future installation of a plug-in unit.
 - b. Provide shutters for each compartment that automatically open when unit is inserted and automatically close when unit is removed.
5. Provide wiring and device identification:
- a. Identify compartment doors, devices, and field wiring in accordance with Section 16075, Identification for Electrical Systems.
 - b. Identify internal control conductors with permanent wire markers. Each wire shall be identified by a unique number attached to wire at each termination point.
 - c. Identify internal control devices with permanent markers. Each device shall be identified by a unique number attached to each device.
 - d. Numbering system for each wire and control device shall be identified on the wiring diagrams in the Shop Drawings and shall reflect the actual designations used in the Work.
6. NEMA 1 minimum motor starter size. Starter units completely draw out type in Sizes 1 and 2 and draw out type after disconnecting power leads only in Sizes 3 and 4.
7. Motor starters shall be NEMA-rated and include magnetic contactor, with encapsulated magnet coils. Wound coils are unacceptable. Control shall be 120 Vac unless indicated otherwise.
- a. Starters shall be full-voltage non-reversing unless shown or indicated otherwise on the Drawings.
 - b. Reversing Starters:
 - 1) Single-speed, full-voltage with two contactors and extra interlocking contacts.
 - c. Reduced Voltage Solid-State Starter:
 - 1) General:
 - a) Provide solid-state, step-less, current limiting, soft-start, motor controllers (RVSS) as shown or indicated on the Drawings.
 - b) RVSS shall be three-phase type and shall include an overload relay and at speed isolation contactor.
 - c) Provide NEMA rated full voltage By-Pass contactor as shown on drawings.
 - c) Provide subsystems that will protect RVSS from damage due to phase loss, over-current and over-voltage.
 - d) Current Rating: 115 percent of motor nameplate rated current, continuous, minimum.

- 2) Required Features:
 - a) Adjustable current limit of not more than 250 percent of motor nameplate full-load current throughout entire motor acceleration period including first three cycles of voltage waveform from instant start signal is engaged.
 - b) Adjustable voltage acceleration, from two to 30 seconds. Acceleration shall be continuous not in steps.
 - c) Adjustable voltage deceleration, from two to 30 seconds. Deceleration should be continuous, not in steps.
 - d) Phase loss detection.
 - e) PUSH-TO-TEST LED diagnostic indicators.
 - f) Static over-current and over-voltage trip.
 - g) Phase reversal, line or fuse loss, and under-voltage protection.
 - h) Power unit over temperature protection.
 - i) Motor inverse time overload protection.
 - j) Input line transient over-voltage protection.
- 3) Enclosure:
 - a) Cooling fans, if required, shall incorporate anti-friction bearings and internal impedance type motor protection.
 - b) If cooling fans are used, enclosure for that section shall be NEMA 12 FVF, or NEMA 12 EFVFF force ventilated with filters, in accordance with NEMA ICS 1-110, installed by motor control center manufacturer.
- 4) On start-up, start driven equipment at zero current and allow driven equipment to accelerate to maximum speed without exceeding the set current limit.
- 5) On normal shutdowns, ramp driven equipment down at set deceleration rate that is non-regenerative for motor prior to shutdown.
- 6) On emergency shutdowns, remove power to motor.
- 7) Diagnostic LEDs: Provide LED (Push to Test) on unit front that indicate the following:
 - a) Control power on.
 - b) Motor power on.
 - c) Motor running.
 - d) Motor fault.
 - e) High Pressure
 - f) RVSS fault.
- 8) Control Outputs:

- a) Control output shall be electrically isolated, dry, normally open SPDT contacts, rated 10 amps at 120 vac.
 - b) Provide the following control outputs:
 - i. Motor running.
 - ii. Motor stopped
 - iii. Motor fault.(Overtemp)
 - iv. High Pressure
 - v. RVSS fault.
8. Overload Relays: Provide an overload relay for each motor starter. Overload relays shall be in accordance with the following:
- a. Electronic Overload Relays: Relays shall be electronic type. Electronic relays shall be multi-function, adjustable, current sensing, type, and include overload, phase-unbalance, phase-loss, and equipment type ground fault in one package.
 - c. Each overload relay shall be manual reset type and shall include provisions for resetting by an insulating button on front of starter unit door.
 - d. Each overload relay shall include a normally-open auxiliary contact for remote alarm purposes.
 - e. Size each overload relay for full-load amperes and service factor of actual motors installed.
9. Individual control power transformers for all starters, capacity as required for all control circuit devices, 150 VA minimum, Class A insulation, two primary fuses, 120-volt secondary, one secondary fuse, and the other secondary leg grounded.
10. Motor horsepower shown are preliminary. Circuit breaker trips and starter overload heaters to be coordinated with the actual equipment installed.
11. Auxiliary contacts, relays, timers as required for specified control functions and those shown on Drawings.
12. Starter devices, including spare contacts, shall be wired to numbered terminal blocks.
13. Terminal blocks for field connections to unit compartments shall be plug-in/pull-apart type. Terminals shall be fully accessible from the front. Terminals shall be mounted near the front of vertical wireway.
14. Control devices shall be 600-volt heavy duty, NEMA A600. Relays shall have convertible contacts. Pilot devices shall be oil tight. Pilot lights shall be transformer type with six-volt secondary. .
15. Feeder Circuit Breakers: LSI adjustable electronic trip thermal magnetic type 100% Rated.
- a. Circuit breakers of 100 amp frame or less shall be 100% rated mounted in a dual mount compartment (two breakers in one space factor) or shall mount in one-half space factor, unless otherwise shown or indicated on the Drawings.
16. Motor Starter Circuit Breakers: Magnetic trip only motor circuit protectors.

17. Provide the following diagrams and tables inside of door for each compartment:
 - a. Elementary wiring diagram.
 - b. Table of overload heater sizes with correct heater highlighted.
 - c. Table of motor circuit protector settings with correct setting highlighted.

18. Where shown or indicated on the Drawings incorporate solid state protective relaying package (SSPRP) into motor starter for motor protection. Unit shall incorporate the ANSI/IEEE C37.2 device function numbers and selectable indications and communication modules indicated below:
 - a. Product and Manufacturer:
 - 1) SqD Power Logic PM 8000.
 - 2) Or MCC manufacturers equal.

 - b. Motor Protection Device Functions:
 - 1) Stator winding over-temperature (Device 49).
 - 2) Short circuit (Device 50).
 - 3) Motor overload (Device 49/50/51).
 - 4) Locked rotor - multiple start (Device 48).
 - 5) Phase reversal (Device 46).
 - 6) Ground fault (Device 50G/51G).
 - 7) Mechanical jam.
 - 8) Unbalance/negative sequence currents (Device 46).
 - 9) Undercurrent (Device 37).
 - 10) Motor bearing over-temperature (Device 38).
 - 11) Thrust bearing over-temperature (Device 38).
 - 12) Over-voltage (Device 59).
 - 13) Undervoltage (Device 27).
 - 14) Voltage sequence (Device 47).
 - 15) Main trip and lockout output relay (Device 86).
 - 16) Alarm output relay (Device 74).

 - c. Selectable Indications:
 - 1) Average motor current.
 - 2) Average motor temperature.
 - 3) Motor current for each of the three phases.
 - 4) Motor temperature readout for six winding RTDs.
 - 5) Motor thrust-bearing temperature readout for two bearing RTDs.
 - 6) Ground fault current.
 - 7) Percent of motor capacity used.
 - 8) Line-to-line and line-to neutral voltages, all three phases.
 - 9) Average 15-minute kVA.
 - 10) Average 15-minute kW.
 - 11) Average 15-minute kVAR.

- 12) Maximum percent full load current since initial startup.
- 13) Hottest RTD and temperature since initial startup.
- 14) Highest percent current unbalance since initial startup.
- 15) Highest ground fault current since initial startup.
- 16) Highest motor bearing temperature since initial startup.
- 17) Highest load bearing temperature since initial startup.
- 18) Maximum line voltage since start.
- 19) Minimum line voltage since start.
- 20) Number of motor starts attempted.
- 21) Number of motor starts completed.
- 22) Hours of operation.
- 23) Number of trips from each of ten protective functions.
- 24) All measured values at the time of a motor trip.
- 25) Values that have been loaded for system inputs and trip points.

d. Communication Module: RS232 capable of uploading all the above protective function attitudes and the above-listed selectable indications upon being queried by a host PLC connected via RS232 communication port.

19. Main and Tie Circuit Breakers: 100% rated, LSIG Electronic trip, thermal magnetic, molded case type, unless shown or indicated otherwise. Mains to have maintenance switch to limit Arcflash exposure.

Where shown or indicated, equip main and tie breakers with PLC and relay interlocking. Interlocking shall allow only two of the three breakers to be closed at a time.

2.03 MAIN METERING DEVICE

- A. Provide a main meter device as shown or indicated on the Drawings.
 1. Microprocessor based monitoring device shall include complete electrical metering in one package. Device shall include self-contained potential transformers and self-protected internal fuses.
 2. Device shall have Ethernet output capabilities and imbedded webpages for communication to SCADA. Provide all gateway equipment as necessary.
 3. Device shall be mounted on compartment door to allow operations and maintenance personnel access to meter menu and display.
 4. Device shall include trend analysis, event logging, and recording. Device shall also include the following direct-reading metered values:

a.	Volts:	0.2 percent accuracy.
b.	Amperes:	0.2 percent accuracy
c.	Watts, Vars and VA:	0.5 percent accuracy
d.	Power Factor:	1.0 percent accuracy
e.	Frequency:	0.05 percent accuracy
f.	Watt, and VA Hours:	0.5 percent accuracy
g.	Var Hours:	1.0 percent accuracy
h.	Watt, Var and VA Demand:	0.4 percent accuracy
i.	THD-Voltage:	50th harmonic

- j. THD-Current: 50th harmonic
- k. Individual Ampere Harmonics: 50th harmonic
- l. Individual Voltage Harmonics: 50th harmonic

- 5. Metering device shall have the following additional features:
 - a. Trend analysis that displays minimum and maximum values for each metered parameter with date and time of each occurrence.
 - b. Input range of device shall accommodate external current transformers with ranges from 100/5 to 5000/5 and potential transformers from a ratio of 120:120 to 500,000:120. Three current transformers suitably rated shall be included.
 - c. Alarm contacts rated five amps at 120 VAC.
 - d. Three analog outputs programmable to reflect the metered parameters, except kilowatt hours and kilovar hours.
 - e. Communication capability, using RS-485, Modbus RTU Protocol.
- 6. Control power shall be drawn from monitored incoming AC line. Device shall have non-volatile memory and not require battery backup. During power failure, device shall retain preset parameters.

2.04 SURGE PROTECTIVE DEVICES

- A. Provide a surge protective device in accordance with Section 16289, Surge Protective Devices, for each motor control center bus shown on the Drawings. Surge protective devices shall be included and factory-mounted within the motor control center by motor control center manufacturer. Surge protective device monitoring and display shall be visible from the motor control center front.

2.05 SOURCE QUALITY CONTROL

- A. Prior to shipping, perform factory tests on motor control centers. Tests shall include manufacturer's standard tests and the following:
 - 1. Physical inspection and checking of components.
 - 2. Mechanical operation and device functionality tests.
 - 3. Primary, control, and secondary wiring hi-pot tests.

PART 3 EXECUTION

3.01 INSPECTION

- A. Examine conditions under which Work is to be installed and notify ENGINEER in writing of conditions detrimental to proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions are corrected.

3.02 INSTALLATION

- A. Install materials and equipment at locations shown or indicated on the Drawings. Install equipment on concrete bases in accordance with the Contract Documents and manufacturer's recommendations and instructions.

- B. For installations against masonry walls, provide an insulation board, 1/4-inch minimum thickness, between motor control center and wall for corrosion protection. Trim board neatly within outline of motor control center.
- C. Openings in top or side of motor control centers for other than conduit entrance are not allowed.
- D. Bundle cable circuits together within enclosures and identify with durable tag secured to cabling twine.
- E. Set motor circuit protectors at lowest setting that allows motor starting without nuisance tripping.
- F. Verify that wiring diagrams on inside of door of each compartment reflect the circuitry actually provided and that correct overload heater size and motor circuit protector setting are noted.
- G. Install in conformance with manufacturer's recommendations, Laws and Regulations, and the Contract Documents.
- H. Connections to existing facilities shall be in accordance with Section 01730, Coordination with Owner's Operations.

3.03 FIELD QUALITY CONTROL

- A. Site Tests:
 - 1. Perform field testing and inspection of motor control centers. Inspect and test each motor control center after installation. Testing and inspection shall be in accordance with the manufacturer's recommendations and the Contract Documents, and be performed by manufacturer's factory-trained representative, Inform OWNER and ENGINEER when equipment is correctly installed, prior to testing. Do not energize equipment without permission of OWNER.
 - 2. Test Equipment, Calibration and Reporting: All test equipment, instrument calibration and test reports shall be in accordance with ANSI/NETA ATS.
 - 3. Perform the following minimum tests and checks before energizing equipment:
 - a. Verify all overload and device settings.
 - b. Inspect mechanical and electrical interlocks and controls for proper operation.
 - c. Check tightness of bolted connections.
 - d. Measure insulation resistance of each bus section, phase-to-phase and phase-to-ground.
 - e. Measure insulation resistance of each starter, phase-to-phase and phase-to-ground.
 - f. Measure insulation resistance of each control circuit with respect to ground.
 - g. Perform other tests recommended by equipment manufacturer.

4. Perform acceptance testing of motor control centers. Inspect and test each motor control center. Testing and inspection shall be performed by the independent testing firm, after completion of field testing specified in Paragraph 3.3.A.3 of this Section.
 - a. Visual and Mechanical Inspection: Perform inspection of each motor control center in accordance with ANSI/NETA ATS. Inspection shall include:
 - 1) Inspect for proper anchorage, damage, and grounding.
 - 2) Verify all overload and device settings.
 - 3) Check tightness of bolted connections.
 5. Electrical Tests: Perform electrical testing of each motor control center in accordance with ANSI/NETA ATS. Testing shall include:
 - 1) Measure insulation resistance of each bus section, phase-to-phase and phase-to-ground.
 - 2) Measure insulation resistance of each starter phase-to-phase and phase-to-ground.
 - 3) Measure insulation resistance of each control circuit with respect to ground.
 - 4) Test motor overload units by current injection.
 - 5) Perform operational tests by initiating control devices for proper operation.
 - 6) Perform contact resistance test and insulation resistance test for each circuit breaker.
 - 7) Determine long-time, short-time, and instantaneous pick-up and delay as required.
- B. Manufacturer's Services: Provide a qualified, factory trained serviceman to perform the following:
1. Supervise unloading and installation of equipment.
 2. Instruct CONTRACTOR in installing equipment.
 3. Inspect, test, and adjust equipment after installation and ensure proper operation.
 4. Instruct operations and maintenance personnel in operation and maintenance of the equipment.
 5. Manufacturer's technician shall make visits to the Site as follows:
 - a. First visit shall be for supervising unloading and handling of equipment and for instructing CONTRACTOR in proper equipment installation, and assisting in installing equipment. Technician shall train installing personnel in advance in proper handling and rigging of equipment. Minimum number of hours on-Site: 2 hours.
 - b. Second visit shall be for checking completed installation, start-up of system; and performing field quality control testing. Technician shall test the system as specified in Article 3.3.A of this Section. Technician shall operate and test the system in the presence of ENGINEER and verify that equipment complies with the Contract Documents and manufacturer's requirements. Technician shall

- adjust the system to initial settings as specified in Article 3.4 of this Section. Minimum number of hours on-Site: 4 hours.
- c. Third visit shall be to instruct operations and maintenance personnel.
 - 1) Furnish services of manufacturer's qualified, factory-trained specialists to instruct OWNER's operations and maintenance personnel in recommended operation and maintenance of equipment.
 - 2) Training requirements, duration of instruction and qualifications shall be in accordance with Section 01730, Instruction of Operations and Maintenance Personnel.
 - 3) Number of hours on-Site shall be in accordance with Section 01730, Instruction of Operations and Maintenance Personnel.
 - d. Technician shall revisit the Site as often as necessary until installation is acceptable.
 - e. Furnish services of manufacturer's factory-trained service technicians to correct defective Work within 72 hours of notification by OWNER during the correction period.
6. All costs, including expenses for travel, lodging, meals and incidentals, and cost of travel time, for visits to the Site shall be included in the Contract Price.

3.04 ADJUSTING

- A. Calibrate, set, and program all protective devices. Coordinate protective devices furnished under this Section and provide proper settings of devices in accordance with the study performed under Section 16215, Electrical Power Distribution System Studies.

3.05 GUARANTEES AND WARRANTIES

- A. The Contractor shall guarantee and warrant all materials and labor provided under this Section for three (3) years from date of Substantial Completion in accordance with Section 01740 and Section 16050 of these Specifications.

END OF SECTION