disable operation to prevent motor damage. The monitor relay shall trip and an error message shall be displayed on the LCD screen when loss of phase occurs and indicate the fault for Remote operation.

I. Discrete remote control may be configured as 2, 3, or 4 wires for open-stop-close control. Remote control functions may be powered by external 24 VDC, 125 VAC, or the actuator's internal supply 24 VDC supply. The voltage values for signal threshold shall be 19.2V AC/DC and 5.0V AC/DC respectively. The maximum load for 24Vdc is 2mA. The internal supplies shall be protected against over current and short circuits faults and utilize optical isolation to minimize electro-magnetic interference. Discrete control shall have an isolated common.

J. ESD (Emergency Shut Down) provision shall be included in each actuator. The actuator shall permit up to three inputs for ESD and they shall be configurable. The ESD signal shall override any existing signal (except LOCAL, STOP, and INHIBIT) and send the valve to its configured emergency position. The ESD may also be configured to override LOCAL, STOP, and/or INHIBIT. Provision for an isolated common shall be provided.

K. Inhibit movement provision shall be included in each actuator. The actuator shall permit up to three inputs for Inhibits and they shall be configurable. Provision for an isolated common shall also be provided.

L. Terminals shall be included to connect the electronic controls package, including display, to a back-up 24 VDC power source. As a standard alternative the actuator shall have the ability to maintain the status and alarm contacts in order to update status to the control room and also provides status visibility on the LCD screen without main power applied. It should be configurable for at least one hour and, once main power is restored, be available for the next unforeseen power outage. The use of an integral battery is prohibited.

M. A dedicated circuit to prevent undesired valve operation in the event of an internal circuit fault or erratic command signal shall be included. A single point failure will not result in erratic actuator movement. An open or short-circuit in the internal circuit board logic shall not energize the motor contactor, nor shall a single fused control relay contact fail to deenergize the motor contactor. The command inputs shall be optically coupled and require a pulse width of at least 250 ms to 350 ms to turn on or off. In the event of an internal circuit fault, an alarm shall be signaled by tripping the Monitor Relay and through LCD indication.

N. Four latched status contacts rated 125VAC, 0.5A and 30VDC, 2 amps shall be provided for remote indication of valve position, configured as 1-N/O and 1-N/C for both the open and closed positions. Two contacts may be configured to represent any other actuator status; mid-travel position, switched to local, overtorque, motor over temperature, manual operation, switched to remote, switched to stop, valve moving, close torque switch, open torque switch, hardware failure, ESD active, inhibits active, valve jammed, analog IP (input) lost, lost phase, and network controlled.

O. A monitor relay shall be included and shall trip when the actuator is not available for remote operation. Both N/O and N/C contacts shall be included, rated 125VAC, 0.5A and 30VDC, 2 amps. The monitor relay shall be configurable for three additional fault indications; lost phase, valve jammed, and motor overtemp. The yellow LED shall blink when the monitor relay is active.

P. The ACP (Actuator Control Panel) cover & module shall use solid-state Hall-effect devices for local communication and configuration. The use of reed switches on the module is prohibited. A 32-character, graphical LCD shall be included to display valve position as a percent of open, 0-100%, and current actuator status. "STATUS OK" shall be displayed for an operable actuator. If the actuator is not operable, the appropriate alarm shall be displayed. The alarm shall be continuously displayed until the actuator is operable. Red, green, and yellow LEDs shall be included for open, close, stopped, and moving indication. The Red and Green LEDs shall be reversible. A padlockable LOCAL-STOP-REMOTE switch and an OPEN-CLOSE switch shall be included for local valve actuator control. The control switches shall not penetrate the controls cover and shall be designed to electrically isolate the actuator's internal components from the external environment. The OPEN-CLOSE switch may be

configured for maintained or push-to-run (inching) control.

Q. The device shall be non-intrusive - All calibration shall be possible without removing any covers and without the use of any special tools. All calibration shall be performed in clear text languages, no icons shall be used. The languages shall be English, Spanish, French, German, Portuguese, Italian, Mandarin, Russian, Malay, and Katakana. All calibration shall be performed by answering the "YES" and "NO" questions displayed on the LCD. "YES" is signaled by using the OPEN switch and "NO" by using the CLOSE switch, as indicated adjacent to the switches. A configurable password option shall be available to prevent unauthorized changes.

R. Double sealed terminal compartment & Terminal block - All customer connections shall be located in a terminal chamber that is separately sealed from all other actuator components. Site wiring shall not expose actuator components to the environment. The internal sealing within the terminal chamber is suitable for NEMA 4, 6, and IP68 to 15M for 96 hours. The chamber shall include screw-type terminals, three for power and 54 for control, for site connections. Three conduit entries, available as: (2) - 1.25" NPT (M32) and (1)-1.5" NPT (M40) shall be located in the terminal chamber.

S. Coatings - The actuator shall be coated with a polymer powder coat. The coating system shall be suitable for an ASTM B117 salt spray test of 1500 hours. External fasteners shall be stainless steel or high-strength carbon steel that has been chromate-hexavalent coated, and then top coated with a high-strength, high-endurance polymer. The fasteners shall be suitable for an ASTM B117 salt spray test of 500 hours.

T. A handwheel and declutch lever shall be provided for manual operation. The handwheel shall not rotate during electric operation nor can a seized motor prevent manual operation. Changing from motor to manual operation is accomplished by engaging the declutch lever. Energizing the motor shall return the actuator to motor operation. The lever to enable the declutch shall be padlockable to permit motor operation only.

U. The actuator shall include a removable torque or thrust bushing to mate with the valve shaft.

V. Diagnostic facilities shall be included to accumulate and report the performance of the motor, encoder, contactor, cycle time, handwheel operations, actuator ID, firmware revision, and output turns. In addition, a torque profile of the reference baseline valve stroke and the last valve stroke shall be included. A feature for reset shall be provided. All diagnostic information shall be displayed on the LCD. Diagnostics shall also include an FDA (Frequency Domain Analysis) feature. The Frequency Domain Analysis methodology shall capture torque, position or speed values at regular time intervals while the actuator is motoring, and calculate the resulting data set with a Fast Fourier Transform [FFT]. The resulting information shall be used to isolate any components in the mechanical drive train that may exhibit excessive wear or may effect normal actuator operation. FDA and resultant fault indications shall be displayed via the graphical LCD. The actuator shall contain the ability for diagnostics information to be downloaded to a PC or PDA via both IRDA and Bluetooth ports.

W. Factory testing - Every actuator shall be factory tested to verify: rated output torque, output speed, handwheel operation, local control, control power supply, valve jammed function, all customer inputs and outputs, motor current, motor thermistor, LCD and LED operation, direction of rotation, microprocessor checks, and position-sensor checks. A report confirming successful completion of testing shall be included with the actuator.

2.05 ACTUATOR CERTIFICATIONS

A. Non-hazardous (Weatherproof/Submersion) Certifications

1. IEC 529 protection code IP68; 15 meters for 96 hours continuous

2. USA & CSA; NEMA 3, 4, NEMA 4X, NEMA 6

B. Standard Hazardous Global certifications:

1. FM – Class I, Groups B, C & D, DIV.1 and Class II, Groups E, F, & G, T4

   a. T4A temperature classification is acceptable w/ operational times < 15 min.

2. ATEX Eex d IIB T4 ATEX II 2 G, CENELEC Norm EN50014 and EN50018

3. ATEX Eex d IIC T4 ATEX II 2 G, CENELEC Norm EN50014 and EN50018

   a. T4A temperature classification is acceptable w/ operational times < 15 min.

4. CSA – Class I, Groups B, C & D, DIV.1 and Class II, Groups E, F, & G, T4

5. IEC Eexd IIB T4, IIB T4

6. IEC Eexd IIC T4, IIC T4

2.06 ACTUATOR OPTIONS

A. Lost power buffer

1. After the actuator has been powered by line power for one hour, it shall automatically withstand most power outages while maintaining the correct state of the S status contacts, even if the user repositions the actuator manually with the handwheel. To maximize its self-power time while the line power is lost, the actuator will place itself in its lowest possible power usage mode. The LCD will darken (sleep mode) until it is needed to be viewed. The LCD can be activated by moving the black knob to OPEN (YES) or by moving the actuator with the handwheel. After 10 seconds of inactivity, the LCD will return to sleep mode.

2. The use of batteries to perform this function shall be prohibited.

B. Analog Position Transmitter (APT)

1. A non-contacting, internally powered, electrically isolated position transmitter shall be included to provide a 4-20 mA signal that is proportional to valve position.

C. Modutronic Option

1. A controller that alters valve position in proportion to a 4-20 mA analog command signal shall be included. Positioning shall be accomplished by comparing the command signal to an internal position feedback. The internal feedback shall be of the non-contacting type. An automatic pulsing feature to prevent overshoot at the setpoint shall be included. Proportional bands, deadband, signal polarity, motion inhibits time, and fail position shall be adjustable through the LCD. Deadband shall be adjustable to 0.5% full span.

D. Relays for Status and Alarms

1. Up to eight additional latching output contacts rated 250 VAC/30 VDC, 5 amps and configurable to represent any actuator status in either N/O or N/C state shall be available: mid-travel position, switched to local, overtorque, motor over temperature, manual operation, switched to remote, switched to stop, valve moving, close torque switch, open torque switch, hardware failure, ESD active, inhibits active, valve jammed, analog IP (input) lost, lost phase, and network controlled.

E. DDC (Distributed Digital Control)

1. Communications with the valve and gate actuators shall use DeviceNet protocol, using trunk and drop cables.

PART 3 - EXECUTION

3.01 INSTALLATION

A. All valves shall be installed in accordance with the manufacturer's recommendations.

B. A qualified factory representative shall provide a minimum of eight (8) hours of training to plant personnel in the operation and maintenance of the equipment.

END OF SECTION

SECTION 11310 – NON-CLOG SUBMERSIBLE SEWAGE PUMPS[ADD2]

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. Provide all labor, materials, equipment, tools and incidentals required for the complete and operable installation of submersible sewage pumps, complete with all appurtenances, including benching and splitters, as shown on the Drawings and more fully described hereinafter.

B. Unless otherwise specified the pump manufacturer shall furnish each pumping unit complete with drive motor and all other components and shall be entirely responsible for the compatibility in all respects of all components furnished.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A.	Cast-In-Place Concrete:	Section 03300
B.	Precision Grouting:	Section 03600
C.	Electrical:	Division 16
D.	Pressure Gauges:	Division 17
E.	Instrumentation:	Division 17
F.	Interior Process Piping:	Section 11290
G.	Interior Process Valves - Sanitary:	Section 11295

1.03 SUBMITTALS

A. Submit manufacturer's data and shop drawings for the materials specified herein. Comply with all requirements of Section 01300.

B. Descriptive literature, catalog cuts, and dimensional prints clearly indicating all dimensions and materials of construction shall be submitted on all items specified herein to the Engineer for review before ordering.

C. At the time of submission, the Contractor shall, in writing, call the Engineer's attention to any deviations that the submittals may have from the requirements of the Engineer's Contract Drawings and Specifications.

D. The Contractor shall provide a notarized certification indicating that all piping products meet the required Specifications.

E. In accordance with the requirements of the General and Special Conditions and this Section, the following table includes, but is not limited to, the items required to be submitted:

Item Description	Shop Drawings	Product Data	Schedules	Installation Data	Parts Lists	Wiring Diagram	Samples	O & M Manual	Certificates	Warranty	Report	Other
Shop Tests									X		X	
Pumps	X			X	X	X		X		X		
Electrical	X				X	X		X				
Field Tests									X		X	

1.04 IDENTIFICATION - NAMEPLATES

A. Each piece of equipment shall be provided with a substantial nameplate, securely fastened in place and clearly inscribed with the manufacturer's name, year of manufacture, serial number and principal rating date.

1.05 TESTS

A. Shop Tests:

1. The pumps shall be fully tested at the manufacturer's works before shipment at their rated speed, capacity, and head, and at such other conditions of head and capacity to establish that each has met all guarantees on the characteristic curves submitted. Five (5) certified copies of the results of these tests are to be sent to the Engineer. Also included with the test curves shall be a certified bill of material list depicting quality of construction. Such tests shall be accomplished at the manufacturer's facility prior to shipment.

2. The pumping units will be accepted upon the basis of the certified copies of the shop test and be subject to a four-hour field test of each unit. This test will be for the purpose of determining if each pumping unit will operate under installed conditions within a reasonable degree of correlation with the shop tests.

B. Field Tests:

1. The Contractor shall give at least two (2) weeks' notice to the Owner when the field tests are to be accomplished so that the Owner may have a representative present at the said tests.

2. The field tests shall be made by the Contractor in the presence of and as directed by the Engineer. Testing shall be done in accordance with the Hydraulic Institute Standards.

3. Field tests shall be made on each pumping unit. Included therein, each pump shall be run at maximum rated speed for at least three (3) rates of flow corresponding to minimum rate, design rate, and maximum rate of flows specified as evidenced by the corresponding total dynamic head shown by the pump gages; simultaneous ammeter readings shall be taken. Variation of the rate of flow shall be made by throttling the discharge valve (where applicable).

The rated motor nameplate current and power shall not be exceeded at any rate of flow within the specified range.

4. Before any pump is rotated, the Contractor shall make certain that no debris is present in suction well, pumps or pipe lines. Any internal damage done to equipment while starting up shall be assumed to be caused by debris and shall be replaced at the Contractor's expense. No pump shall be rotated under power unless submerged with liquid.

5. When water can be pumped, the Contractor shall commence pumping and shall have representatives from the pump manufacturer to start the pumps. When flow conditions are favorable, the Contractor or pump manufacturer shall in the presence of the Engineer, run a series of tests to establish the adequacy of the pumping units.

6. Field tests shall also conform to Part 3, Paragraph 3.3 as specified hereinafter.

C. Failure of Tests:

1. Any defects in the equipment or failure to meet the guarantees or requirements of the specifications shall be promptly corrected by the Contractor by replacements or otherwise. The decision of the Engineer as to whether or not the Contractor has fulfilled his obligations under the Contract shall be final and conclusive. If the Contractor fails or refuses to make these corrections or if the improved equipment, when tested, shall fail again to meet the guarantees of specified requirements, the Owner notwithstanding its having made partial payment for work and materials which have entered into the manufacture of said equipment, may reject said equipment and order the Contractor to remove it from the premises at his own expense.

2. In case the Owner rejects said equipment, then the Contractor hereby agrees to repay to the Owner all sums of money paid to him for said rejected equipment on progress certificates, and upon the receipt of said sum of money the Owner will execute and deliver to the Contractor a bill of sale of all its rights, title, and interest in and to said rejected equipment; provided, however, that said equipment shall not be removed from the premises of the Owner until the Owner obtains from other sources the equipment to take the place of the rejected. The Owner hereby agrees to obtain said other equipment within a reasonable time and the Contractor agrees that the Owner may use the equipment furnished by him without rental or other charge until said other new equipment is obtained.

D. Responsibility During Test: The Contractor shall be fully responsible for the proper operation of equipment during tests and instruction periods and shall neither have nor make any claim for damage which may occur to equipment prior to the time when the Owner formally takes over the operation thereof.

E. Manufacturer's Representative: For all pumping units, the Contractor shall furnish the services of accredited representatives of the pump manufacturer who shall supervise the installation, adjustment, and field tests of each pumping unit and give instructions to the operating personnel. As one condition necessary to acceptance of any pumping unit, the Contractor shall submit a certificate from the manufacturer, stating that the installation of the pumping unit is satisfactory, that the unit is ready for operation, and that the operating personnel have been suitably instructed in the operation, lubrication, and care of the unit.

1.06 GUARANTEE PERIOD

A. After successful completion of tests and trials under operating conditions on all equipment, the Contractor shall guarantee all equipment and materials from undue wear

and tear from mechanical and electrical defects, and from any failure whatever except those resulting from proven carelessness or deliberate actions of the Owner, for a minimum of one (1) year. This one (1) year minimum shall not replace a standard manufacturer's guarantee if it exceeds one (1) year.

1.07 PUMP WARRANTY

A. The Contractor guarantees and warrants that during the first year of operation, the pumps will operate satisfactorily and continuously according to the pump schedule specified herein, and that after due notice has been given by the Owner, he or the pump manufacturer will proceed, within a reasonable time, to adjust, regulate, repair and renew at his own expense or perform such work as is necessary to maintain the guaranteed capacities, efficiencies and performances.

PART 2 - PRODUCTS

2.01 SUBMERSIBLE NON-CLOG SEWAGE PUMPS

A. Submersible pumping equipment shall include motor driven submersible non-clog sewage pumps, pump retrieval systems, required piping, electrical controls, automatic pumping level controls, slide rails, grout benching, stainless steel splitters, and other required appurtenances and wiring.

2.02 SUBMERSIBLE PUMPS AND APPURTENANCES

A. Equipment shall comply with the following characteristics in the Pump Schedule:

Pump Station Schedule

Fill Pumps

Xylem Flygt CP 3531/865 3 ~ 1040, 685 mm Impeller

Total No. of Pumps	Shutoff Head (ft.)	Design Point (Flow/TDH)	Additional Point (Flow/TDH)	Additional Point (Flow/TDH)	Rated Motor Speed (rpm)	Impeller Type	Motor Each (HP)	Motor Voltage	Hydraulic Efficiency (%)	Discharge Connection Diameter (in.)	NPSH
4	129	14,000 gpm @ 74.7 ft TDH	10,000 gpm @ 90.5 ft TDH	17,000 gpm @ 59.5.0 ft TDH	710 rpm	Multi-channel impeller	335 Hp	460V 3 Phase	85.1% @ 14,000 gpm	20 in.	<24ft. @ 16,000 gpm

OR

~~ABS XFP 500U CH3~~ ABS AFP5002-CH3 M2800/8[ADD5], 570 mm impeller diameter

Total No. of Pumps	Shutoff Head (ft.)	Design Point (Flow/TDH)	Additional Point (Flow/TDH)	Additional Point (Flow/TDH)	Rated Motor Speed (rpm)	Impeller Type	Motor Each (HP)	Motor Voltage	Hydraulic Efficiency (%)	Discharge Connection Diameter (in.)	NPSH
4	131	14,000 gpm @ 70.7 ft TDH	10,000 gpm @ 96 ft TDH	17,000 gpm @ 59.5.0 ft TDH	890	Multi-channel impeller	345	460V 3 Phase	79% @ 14,000 gpm	20 in.	<24ft. @ 16,000 gpm

OR

Ebara 500DSC3, E2244-885U, 566 mm

Total No. of Pumps	Shutoff Head (ft.)	Design Point (Flow/TDH)	Additional Point (Flow/TDH)	Additional Point (Flow/TDH)	Rated Motor Speed (rpm)	Impeller Type	Motor Each (HP)	Motor Voltage	Hydraulic Efficiency (%)	Discharge Connection Diameter (in.)	NPSH
4	118	14,000 gpm @ 70 ft TDH	10,000 gpm @ 90 TDH	17,000 gpm @ 50.0 ft TDH	885	Multi-channel impeller	335	460V 3 Phase	85% @ 14,000 gpm	20 in.	<24ft. @ 16,000 gpm

Low Flow Pumps Schedule

Total No. of Pumps	Shutoff Head (ft.)	Design Point (Flow/TDH)	Additional Point (Flow/TDH)	Additional Point (Flow/TDH)	Rated Motor Speed (rpm)	Impeller Type	Motor Each (HP)	Model	Motor Voltage	Hydraulic Efficiency (%)	Discharge Connection Diameter (in.)
2	58 gpm @ 40.2 ft TDH	1 pump running: 172 gpm @ 33 ft TDH	1 pump running: 240 gpm @ 27 ft TDH	1 pump running: 320 gpm @ 19 ft TDH	1,750 rpm	Vortex impeller	5.3 Hp	**ABS** XFP 80C VX w/185 mm impeller or approved equal	460 V 3 Phase	40.70%	3 in.

B. Manufacturers:

1. The pump and motor shall be from the same manufacturer.
2. The pump and motor manufacturer shall be ABS, Flygt, or Ebara, or approved equal.

C. Pump Requirements:

1. Furnish and install submersible non-clog wastewater pumps as indicated in the pump schedule. Power cable shall be SUBCAB type suitable for submersible pump applications. The power cable shall be sized according to NEC and ICEA standards. Sufficient power and control cable lengths shall as determined by the Contractor. Stainless steel strain relief cable grips shall be furnished and installed for each end of the pump power and control cables.

D. Pump Design:

1. The pump shall be supplied with a mating cast iron discharge connection as shown in the pump schedule. The pumps shall be automatically and firmly connected to the discharge connection, guided by no less than two 304 SS guide bars extending from the top of the station to the discharge connection. There shall be no need for personnel to enter the wet-well. Sealing of the pumping unit to the discharge connection shall be accomplished by a machined metal to metal or O-ring watertight contact. Sealing of the discharge interface with a diaphragm will not be acceptable. No portion of the pump shall bear directly on the sump floor. Each pump shall be fitted with 30 feet of 316 Stainless lifting chain. The working load of the lifting system shall be 50% greater than the pump unit weight.

E. Pump Construction:

1. Major pump components shall be of grey cast iron, ASTM A-48, Class 35B, with smooth surfaces devoid of blow holes or other irregularities. The lifting handle shall be of stainless steel. All exposed nuts or bolts shall be of 316 stainless construction. All metal surfaces coming into contact with the pumpage, other than stainless steel or brass, shall be protected by a factory applied spray coating of acrylic dispersion zinc phosphate primer with a polyester resin paint finish on the exterior of the pump.
2. Sealing design shall incorporate metal-to-metal or O-ring contact between machined surfaces. Critical mating surfaces where watertight sealing is required shall be machined and fitted with Nitrile rubber O-rings. Fittings will be the result of controlled compression of rubber O-rings in two planes and O-ring contact of four sides without the requirement of a specific torque limit.
3. Rectangular cross sectioned gaskets requiring specific torque limits to achieve compression shall not be considered as adequate or equal. No secondary sealing compounds, elliptical O-rings, grease or other devices shall be used.

F. Cooling System:

1. Each unit shall be provided with an integral motor cooling system. A stainless steel or epoxy coated steel motor cooling jacket shall encircle the stator housing, providing for dissipation of motor heat regardless of the type of pump installation. An impeller, integral to the cooling system and driven by the pump shaft, shall provide the necessary circulation of the cooling liquid through the jacket. The cooling liquid shall pass about the stator housing in the closed loop system in turbulent flow providing for superior heat transfer. The cooling system shall have one fill port and one drain port integral to the cooling jacket. The cooling system shall provide for continuous pump operation in liquid or ambient temperatures of up to 104°F (40°C). Operational restrictions at temperatures below 104°F are not acceptable. Fans, blowers or auxiliary cooling systems that are mounted external to the pump motor are not acceptable.

OR

The motor design shall include an integral cooling jacket constructed of steel, A283, Grade D. The cooling medium shall be the pumpage. Re-circulation through the jacket shall be achieved by discharging the pumpage into the cooling jacket from the periphery, high pressure area, of the impeller, and returning it into the low pressure behind the impeller, at the hub. Riser pipes within the jacket shall be utilized to facilitate circulation. The cooling passage ways shall be non clogging by virtue of the dimensions; screening solids from entering the jacket. The jacket shall have may have external NPT connections to be used for external cooling as an option, as well as for venting the jacket. The jacket cooling system shall provide heat dissipation for the motor whether the unit is submerged or operating in air. The cooling system shall provide for continuous pump operation in liquid or ambient temperatures of up to 104°F (40°C). Operational restrictions at temperatures below 104°F are not acceptable. Fans, blowers or auxiliary cooling systems that are mounted external to the pump motor are not acceptable.

G. Cable Entry Seal:

1. The cable entry seal design shall preclude specific torque requirements to insure a watertight and submersible seal. The cable entry shall consist of dual cylindrical elastomer grommets, flanked by washers, all having a close tolerance fit against the cable outside diameter and the entry inside diameter. The grommets shall be compressed by the cable entry unit, thus providing a strain relief function. The assembly shall provide ease of changing the cable when necessary using the same entry seal. The cable entry junction chamber and motor shall be sealed from each other, which shall isolate the stator housing from foreign material gaining access through the pump top. Secondary epoxy sealing systems shall not be considered equal.

H. Motor:

1. The pump motor shall be a NEMA B design, induction type with a squirrel cage rotor, shell type design, housed in an air filled, watertight chamber. The stator windings shall be insulated with moisture resistant Class H insulation rated for 180°C (356°F). The motor shall be designed for continuous duty while handling pumped media of up to 104°F. The motor shall be capable of no less than 15 evenly spaced starts per hour. The rotor bars and short circuit rings shall be made of aluminum. Three thermal switches shall be embedded in the stator end coils, one per phase winding, to monitor the stator temperature. These thermal switches shall be used in conjunction with and supplemental to external motor overload protection and shall be connected to the motor control panel. See Contract Drawings for Electrical Schematics.
2. The junction chamber shall be sealed off from the stator housing and shall contain a terminal board for connection of power and pilot sensor cables using threaded compression type terminals. The use of wire nuts or crimp-type connectors is not acceptable.
3. The motor service factor (as defined by NEMA MG1 standard) shall be ~~1.15~~ *1.10*[ADD5] minimum. The motor shall have a voltage tolerance of +/- 10%. The motor shall be designed for continuous operation in up to a 40°C ambient and shall have a NEMA Class A maximum operating temperature rise of 80°C. A motor performance chart shall be provided upon request exhibiting curves for motor torque, current, power factor, input/output kW and efficiency. The chart shall also include data on motor starting and no-load characteristics. Motor horsepower shall be sufficient so that the pump is non-overloading throughout its entire performance curve, from shut-off to run-out. The motor and cable shall be capable of continuous submergence underwater without loss of watertight integrity to a depth of 65 feet or greater.
4. The motor shall be approved by Factory Mutual as explosion proof for use in NEC CLASS I, DIVISION 1, GROUP C&D HAZARDOUS LOCATIONS.
5. Supply voltage for each motor shall be 460-volt, 3-phase, 60 Hz.

I. Bearings:

1. The integral pump/motor shaft shall rotate on a minimum two bearings. The motor bearings shall be sealed and permanently grease lubricated with high temperature grease. The upper motor bearing shall be a two row angular contact ball bearing. The lower bearing shall be a two row angular contact ball bearing to handle the thrust and radial forces. L-10 bearing life shall be a minimum of 100,000 hours at flows ranging from ½ of BEP flow to 1½ times BEP flow (BEP is best efficiency point).

J. Mechanical Seals:

1. Each pump shall be provided with a positively driven dual, tandem mechanical shaft seal system consisting of two seal sets, each having an independent spring. The lower primary seal, located between the pump and seal chamber, shall contain one stationary and one positively driven rotating corrosion and abrasion resistant silicon carbide or tungsten-carbide ring. The upper secondary seal, located between the seal chamber and the seal inspection chamber shall be a leakage-free seal. The upper seal shall contain one stationary and one positively driven rotating corrosion and abrasion resistant silicon carbide or tungsten-carbide seal ring. The rotating seal ring shall have small back-swept grooves laser inscribed upon its face to act as a pump as it rotates, returning any fluid that should enter the dry motor chamber back into the lubricant chamber. All seal rings shall be individual solid sintered rings. Each seal interface shall be held in place by its own spring system. The seals shall not depend upon direction of rotation for sealing. Mounting of the lower seal on the impeller hub is not acceptable. Shaft seals without positively driven rotating members or conventional double mechanical seals containing either a common single or double spring acting between the upper and lower seal faces are not acceptable. The seal springs shall be isolated from the pumped media to prevent materials from packing around them, limiting their performance. The mechanical seal hardware shall be 316SS.

OR

The mechanical seal system shall be a cartridge mounted double mechanical seal in a tandem arrangement. Each seal shall be positively driven and act independently with its own spring system. The upper seal operates in an oil bath, while the lower seal is lubricated by the oil from between the shaft and the seal faces, and in contact with the pumpage. The oil filled seal chamber shall be designed to prevent over-filling and include an anti-vortexing vane to insure proper lubrication of both seal faces. Lower face materials shall be Silicon Carbide or Tungsten Carbide seal ring, upper faces be Silicon Carbide or Tungsten Carbide seal ring. NBR elastomers shall be provided in the oil chamber and viton elastomers where in contact with the pumpage. The mechanical seal hardware shall be 316SS. Seal system shall not rely on pumping medium for lubrication.

2. Each pump shall be provided with a lubricant chamber for the shaft sealing system. The lubricant chamber shall be designed to prevent overfilling and shall provide capacity for lubricant expansion. The seal lubricant chamber shall have one drain and one inspection plug that are accessible from the exterior of the motor unit. The seal system shall not rely upon the pumped media for lubrication.
3. The area about the exterior of the lower mechanical seal in the cast iron housing shall have cast in an integral concentric spiral groove. This groove shall protect the seals by causing abrasive particulate entering the seal cavity to be forced out away from the seal due to centrifugal action.
4. A separate seal leakage chamber shall be provided so that any leakage that may occur past the upper, secondary mechanical seal will be captured prior to entry into the motor stator housing. Such seal leakage shall not contaminate the motor lower bearing. The leakage chamber shall be equipped with a float type switch and/or probe electrical that will signal if the chamber should reach 50% capacity.
5. The seal system shall not rely upon the pumped media for lubrication and shall not be damaged when the pump is run dry. Lubricant in the chamber shall be environmentally safe non toxic material.

K. Pump Shaft:

1. The pump and motor shaft shall be a single piece unit. The pump shaft is an extension of the motor shaft. Shafts using mechanical couplings shall not be acceptable. The shaft shall be stainless steel – ASTM A479 S43100-T, Stainless steel AISI 403, or a C54N carbon steel shaft with an A276 Type 420 stainless steel shaft sleeve.

L. Impeller:

1. The Flygt impeller shall be of Hard-Iron™ (ASTM A-532 (Alloy III A) 25% chrome cast iron), dynamically balanced, semi-open, multi-vane, back swept, screw-shaped, non-clog design. The impeller leading edges shall be mechanically self-cleaned automatically upon each rotation as they pass across a spiral groove located on the volute suction. The leading edges of the impeller shall be hardened to Rc 60 and shall be capable of handling solids, fibrous materials, heavy sludge and other matter normally found in wastewater. The screw shape of the impeller inlet shall provide an inducing effect for the handling of up to 5% sludge and rag-laden wastewater. The impeller to volute clearance shall be readily adjustable by the means of a single trim screw. The impeller shall be locked to the shaft, held by an impeller bolt and shall be coated with alkyd resin primer.

OR

2. The ABS channel impeller shall be of gray cast iron, EN-GJL-250 (ASTM A-48, Class 35B). The impeller shall be of the double shrouded, non-clogging, three vane design. The impeller shall be capable of passing a minimum of 7.9" x 4.9" inch oblong solids or 4 inch spherical solids. The impeller shall have a slip fit onto the motor shaft and drive key, and shall be securely fastened to the shaft by a stainless steel bolt which is mechanically prevented from loosening by a positively engaged ratcheting washer assembly. The head of the impeller bolt shall be effectively recessed within the impeller bore or supporting washer to prevent disruption of the flow stream and loss of hydraulic efficiency. The impeller shall be dynamically balanced to the ISO 10816 standard to provide smooth vibration free operation.

OR

3. The Ebara impeller shall be a non-clog, enclosed, multi-vane mixed flow type. It shall be dynamically balanced and shall be designed for solids handling with a long thrulet without acute turns. The inlet edge of the impeller vanes shall be angled toward the impeller periphery so as to facilitate the release of objects that might otherwise clog the pump. The design shall also include back pump out vanes to reduce the pressure and entry of foreign materials into the mechanical seal area. Impellers shall be direct connected to the motor shaft with a slip fit, key driven, and secured with an impeller nut. The design shall include an optional, replaceable wear ring manufactured of AISI 304SS material to maintain working clearances and hydraulic efficiencies.

M. Wear Ring System:

1. A replaceable wear ring of stainless steel 1.4581 (AISI 318) or brass shall be securely fitted into the pump casing (volute). The impeller wear ring shall be stainless steel 1.4571 (AISI 316Ti) or equal.

N. Volute/Suction Cover:

1. The Flygt pump volute shall be a single piece gray cast iron, ASTM A-48, Class 35B, non-concentric design with smooth passages of sufficient size to pass any solids that may enter the impeller. Minimum inlet and discharge size shall be as specified. The volute shall have a replaceable suction cover insert ring in which are cast spiral-shaped, sharp-edged groove(s). The spiral groove(s) shall provide trash release pathways and

sharp edge(s) across which each impeller vane leading edge shall cross during rotation so to remain unobstructed. The insert ring shall be cast of Hard-Iron™ (ASTM A-532 (Alloy III A) 25% chrome cast iron) and provide effective sealing between the multi-vane semi-open impeller and the volute housing.

OR

2. The ABS pump volute shall be single piece gray cast iron, EN-GJL-250 (ASTM A-48, Class 35B) non –concentric design with centerline discharge. Passages shall be smooth and large enough to pass any solids which may enter the impeller. Discharge size shall be as specified on the pump performance curve. The discharge flange design shall permit attachment to standard ANSI. The discharge flange shall be drilled to accept either ANSI class 125. Discharge elbow shall be ANSI Class 125. Proprietary or non standard flange dimensions shall not be considered acceptable. The suction flange shall be integrated into the volute and its bolt holes shall be drilled and threaded to accept standard ANSI class 125 flanged fittings. The minimum working pressure of the volute and pump assembly shall be 10 bar (145 psi).

OR

3. The Ebara casing design shall be of ASTM A-48, Class 35B gray cast iron and centerline discharge with a large radius on the cut water to prevent clogging. Units shall be furnished with a discharge elbow and 125 lb. flat face ANSI flange. A replaceable casing ring shall be provided, manufactured of AISI 403SS material, to maintain working clearances and hydraulic efficiencies. All exposed bolts and nuts shall be 304 stainless steel. All mating surfaces of major components shall be machined and fitted with NBR O-rings where watertight sealing is required. Machining and fitting shall be such that sealing is accomplished by automatic compression of O-rings in two planes and O-ring contact is made on four surfaces without the requirement of specific torque limits. Surfaces in contact with the pumpage shall be surface prepared to SSPCSP-10 and coated with three (3) coats of coal tar epoxy paint. The internal surface of the motor shall be surface prepared to SSPC-SP-3 and coated with one (1) coat of zinc rich primer paint. Surfaces in air shall be surface prepared to SSPC-SP-10 and coated with one (1) coat of zinc chromate primer and one (1) coat of alkyd resin enamel paint.

O. Protection:

1. Each pump motor stator shall incorporate three thermal switches, one per stator phase winding and be connected in series, to monitor the temperature of the motor. Should the thermal switches open, the motor shall stop and activate an alarm.
2. Bearing temperature switches shall also be installed for the upper and lower bearing housings.
3. A float switch shall be installed in the seal leakage chamber for each seal and will activate if leakage into the chamber reaches 50% chamber capacity, signaling the need to schedule an inspection.
4. Moisture sensing probes shall be provided in the electrical connection chamber and the motor chamber.
5. The thermal switches and float switch shall be connected to a Mini CAS control and status monitoring unit, for Flygt pumps, or equal, for ABS or Ebara pumps, to take signal and relay signals from pump. The Mini CAS unit shall be designed to be mounted in the pump control panel. The units shall provide alarm information.

P. Guide Rail Base Assembly

1. There shall be no need for personnel to enter the wet well to remove or reinstall the pump(s). In a wet pit installation, the discharge base & elbow assembly shall be permanently installed in the wet well and connected to the discharge piping. In order to

prevent binding or separation of the pump from the guide rail system, the pump(s) shall connect to the guide rail base automatically and firmly, guided by two 2 inch 304 SS guide pipes extending from the base elbow to the top of the station. Systems using guide cable in lieu of rigid guide bars or pipes shall not be considered acceptable. The sliding guide bracket shall be a separate part of the pumping unit, capable of being attached to standard 20 inch ANSI class 125 or metric DN500 pump flanges, so that the pump mounting is non-proprietary, and any pump with a standard discharge flange can be mounted on the base assembly. Base or bracket assemblies with proprietary or non standard flange dimensions shall not be considered acceptable.

A field replaceable Nitrile (Buna-N) rubber profile gasket or o-ring shall accomplish positive sealing of the pump flange/guide rail bracket to the discharge elbow. Base assemblies which rely solely on metal to metal contact between the pump flange and discharge base elbow as a means of sealing are inherently leak prone, and shall not be considered equal. No portion of the pump shall bear directly on the floor of the sump. The guide rail system shall be available in an optional non-sparking version, approved by Factory Mutual for use in NEC Class 1, Division 1, Group C&D hazardous locations.

Q. Pump Retrieval System:

Each submersible pump shall be furnished with a pump lifting-chain positive-recovery system consisting of the following components:

1. A minimum of the depth of chamber plus 5 feet of nylon or stainless steel line, of diameter matching weight of lifting chain required, connected to a short length (approximately ten links long) of high tensile strength proof-tested chain of required capacity, connected to the lifting eye or lifting bail of the submersible pump.
2. A forged "grip-eye" or "grab link" of wrought alloy steel, provided separately to connect to the end of the lifting cable or chain of the pump lifting device. The operation of the pump lifting-chain positive-recovery system shall be as follows:

    a. Connect small eye of "grip-eye" or "grab link" to end of chain or cable of external mechanical of lifting device.
    b. Slip top end of nylon or stainless steel line through large eye of "grip-eye" or "grab link".
    c. Lower "grip-eye" or "grab link" to top of pump while maintaining a taut nylon or stainless steel line, making sure short length of chain fastened to pump is also taut.
    d. Release tension on nylon or stainless steel line when "grip-eye" or "grab link" has reached pump top. Make certain upper end of nylon or stainless steel line has been secured.
    e. Take up tension on cable or chain of lifting device, "grip-eye" or "grab link" will engage links of short chain and lift pump.

R. Coatings:

1. Pumps shall be provided with manufacturer's standard coating system.

S. Inlet Flow Protection (Anti-Vortex):

1. The pump manufacturer shall also supply an intake splitter plate for each pump. The splitter shall be fabricated of ½-inch thick AISI type 304 stainless steel, and be constructed with integral tabs for anchoring to the floor. The splitter shall be centered underneath the pump inlet to prevent swirl formation at the pump. Pump manufacturer is responsible for confirming splitter dimensions during the submittal process.

T. Lifting Chain Support Bracket

1. A 304 SS Lifting Chain support bracket shall be installed at the opening, beneath each pump hatch. The bracket shall be fabricated to support the two times the weight of the chain without deflection or damage. Contractor shall coordinate and install bracket.

2.4 PRESSURE GAUGES

A. See Division 17 – Instrumentation for pressure gauge specification and schedule.

PART 3 - EXECUTION

3.1 PREPARATION

A. Coordinate with other trades, equipment and systems to the fullest extent possible.

B. Take all necessary measurements in the field to determine the exact dimensions for all work and the required sizes of all equipment under this contract. All pertinent data and dimensions shall be verified by the Contractor.

3.2 INSTALLATION

A. Installation shall be in strict accordance with the manufacturer's instructions and recommendations in the locations shown on the Drawings. Anchor bolts shall be set in accordance with the manufacturer's recommendations and setting plans.

B. The Contractor shall also provide from the submersible pump supplier the service of a qualified start-up engineer (factory representative) who has had prior on-site start-up experience to assist in performing start-up, check-out and initial operation services of the pumping units. The start-up engineer shall also instruct the Owner's personnel on the operation and maintenance procedures for the station. Qualified supervisory services, including manufacturers' engineering representatives, shall be provided for a minimum of two (2) man-days to insure that the work is done in a manner fully approved by the respective equipment manufacturer. The pump manufacturer's representatives shall specifically supervise the installation of the pump and the alignment of the connection piping. If there are difficulties in the start-up or operation of the equipment due to the manufacturer's design or fabrication, additional service shall be provided at no cost to the Owner. Services of the manufacturer's representatives and training shall be provided when the first pump is started, with follow-up visits upon start-up of each subsequent pump.

C. A certificate from each equipment manufacturer shall be submitted stating that the installation of his/her equipment is satisfactory, that the equipment is ready for operation and that the operating personnel have been suitably instructed in the operation, lubrication and care of each unit.

3.3 FIELD TESTS

A. During the field tests, observations shall be recorded of head, capacity, and motor input. All defects or defective equipment revealed by or noted during the tests shall be corrected or replaced promptly at the expense of the Contractor, and if necessary, the tests shall be repeated until results acceptable to the Engineer are obtained. The Contractor shall furnish all labor, piping, equipment, and materials necessary for conducting the tests. A report of the field tests shall be submitted to the Engineer.

B. After installation of the pumping equipment, and after inspection, operation, testing and adjustment have been completed by the manufacturer's representative, each pump shall be given a running test in the presence of the Engineer, such tests as necessary to indicate that the pumps, motors, and drives generally conform to the efficiencies and operating conditions specified and its ability to operate without vibration or overheating. The pumps and motors shall operate at the specified capacities in the range of heads specified without undue noise or vibration. Any undue noise or vibration in the pumps or motors, which is objectionable, will be sufficient cause for rejection of the units.

~~C. A thirty-day operating period of the pumps will be required before acceptance. If a pump performance does not meet the Specifications, corrective measures shall be taken or the pump shall be removed and replaced with a pump which satisfies the conditions specified. All test procedures shall be in accordance with Hydraulic Institute Standard ANSI/HI 11.6 *Rotodynamic Submersible Pumps for Hydraulic Performance, Hydrostatic Pressure, Mechanical, and Electrical Acceptance Tests.*~~

C. *A thirty-day consecutive operating period of the pumps will be required before acceptance. It is understood that rain events may not occur during this period. Operation of the facility will be conducted by closing gates and activating the pump station into a simulated storm situation. If a pump performance does not meet the Specifications, corrective measures shall be taken or the pump shall be removed and replaced with a pump which satisfies the conditions specified. All test procedures shall be in accordance with Hydraulic Institute Standards certified results of tests shall be submitted. All power costs during this period of operation of the pump station will be paid for by the LFUCG. However, after the 30-day operating period and the pumps have not been accepted, the Contractor shall be responsible for these costs.*[ADD6]

D. Provide, calibrate and install all temporary gauges and meters, shall make necessary tapped holes in the pipes, and install all temporary piping and wiring required for the field acceptance tests. Written test procedures shall be submitted to the Engineer for approval 30 days prior to testing.

3.5 TRAINING

A. A factory representative shall provide a minimum of eight (8) man-hours of training to the Owner's operations staff concerning the recommended operation and maintenance of the equipment. Training shall be performed after substantial completion of the project with the use of operating equipment.

END OF SECTION

DIVISION 13

SPECIAL CONSTRUCTION

SECTION 13201 - PRESTRESSED CONCRETE STORAGE TANK

PART 1 GENERAL

1.01 SECTION INCLUDES

A. This section specifies the design and construction of an AWWA D110 Type II, wire-wound prestressed concrete storage tank with steel diaphragm complete including all reinforcing, concrete work, accessories, disinfection and testing directly related to the tank.

B. The tank contractor is responsible for furnishing all labor, materials, tools, equipment and supervision necessary to design and construct the prestressed concrete storage tank as indicated on the drawings and as described in this specification.

1,02 RELATED SECTIONS

A. Section 00320 – Geotechnical Data

B. Section 02300 – Earthwork.

C. Section 02475 – Drilled Shafts

1.03 REFERENCES

A. ACI 372R-03 – Design and Construction of Circular Wire- and Strand-Wrapped Prestressed Concrete Structures.

B. AWWA D110-04 – Wire- and Strand-Wound, Circular, Prestressed Concrete Water Tanks.

C. ACI 506R – Guide to Shotcrete.

D. ASTM A 821/A821M – Standard Specification for Steel Wire, Hard Drawn for Prestressing Concrete Tanks.

E. ASTM A 1008/A1008M – Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy With Improved Formability.

F. ASCE Standard 7-05 – Minimum Design Loads for Buildings and Other Structures.

G. ASTM C 881/C881M – Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete.

H. ASTM A 416/A416M – Standard Specification for Steel Strand, Uncoated Seven-Wire for Prestressed Concrete.

I. ASTM A 884/A884M – Standard Specification for Epoxy Coated Steel Wire and Welded Wire Reinforcement.

J. ASTM A 185 – Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete.

K. ASTM A 615 – Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.

L. ACI 305R – Hot Weather Concreting.

M. ACI 306R – Cold Weather Concreting.

N. ACI 350 – Building Code Requirements for Environmental Engineering Concrete Structures and Commentary.

O. ASTM C 31/C31M – Test Methods for Making and Curing Concrete Test Specimens in the Field.

P. ASTM C 39/C39M – Test Method for Compressive Strength of Cylindrical Concrete Specimens.

Q. ASTM C 231 – Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.

R. ASTM C 143 – Standard Test Method for Slump of Hydraulic-Cement.

S. ASTM C 172 – Standard Practice for Sampling Freshly Mixed Concrete.

T. ASTM C 33/C33M – Specification for Concrete Aggregates.

U. ASTM D 1056 – Standard Specification for Flexible Cellular Material.

1.04 SUBMITTALS

A. Shop Drawings: The successful bidder shall provide shop drawings with a minimum size of 18" x 24" with a complete plan, elevation, and sectional views showing critical dimensions as follows:

1. Size, location and number of all reinforcing bars.
2. Thickness of all parts of the tank structure including floor, core wall, and covercoat.
3. Prestressing schedule including number and placement of prestressing wires on the tank wall and total applied force per foot of wall height.
4. Location and details of all accessories required.
5. Foundation design for cased, drilled shafts.
6. *Construction joint layout and concrete placement sequence for the slab of the storage tank shall be part of the delegated engineered design and submitted for approval. Should continuous concrete placement design be considered, the Contractor shall submit their construction sequence and affidavit from each of the concrete material suppliers that all materials and deliveries will be available for the continuous period of placement.*[ADD4]

B. Concrete Data: Submit concrete design mixes including ingredient proportions, minimum cementitious content, and water/cementitious ratio in accordance with Section 2.2 and 2.3 of this specification.

C. Design Data: Submit structural calculations and drawings for the tank, signed and sealed by a professional engineer in accordance with Section 1.05A.3 of this specification.

D. Test Reports: Submit concrete strength reports for 7-day and 28-day breaks taken in accordance with the requirements of Section 3.03.A.1. **Concrete sampling and testing will be performed by a Geotechnical firm employed approved by the Owner and compensated by the Contractor.**

E. Warranty Document: Submit warranty document in Owner's name in accordance with Section 1.6 A. of this specification.

F. Cleaning Plan: Submit a cleaning plan which complies with Section 3.04 of this specification.

G. Project Record Documents: Record actual location layout and final configuration of tank and accessories on shop drawings and submit to Engineer after construction of the tank is complete.

1.05 QUALITY ASSURANCE

A. Qualifications and Experience:

1. Tank Construction Company: Shall be a firm with five (5) years of experience in the design and construction of AWWA D110 Type II wire-wound, circular prestressed concrete tanks with satisfactory evidence that it has the skill, reliability, and financial stability to build and guarantee the tank in accordance with the quality required by these specifications. The company constructing the tank shall have built completely in its own name in the past five years, and be presently responsible for, a minimum of two (2) prestressed composite tanks of equal or greater size than that required for this project which meet these specifications and are now providing satisfactory service.
2. Construction: The entire tank, including all portions of the floor and wall shall be built by the tank construction company, using its own trained personnel and equipment.
3. Design: All design work for the tank shall be performed by a professional engineer with no less than five years of experience in the design and construction of AWWA D110 Type II wire-wound, circular prestressed concrete tanks. The professional engineer shall be a full-time staff member of the tank construction company and shall be licensed to work in the Commonwealth of Kentucky.
4. The steel shell design and epoxy injection procedure shall have been used in the two (2) tanks required in Section 1.05 A. of this specification.

B. Bid Submittal:

1. All tank construction companies must submit verification with their bid *or prior to award*[ADD4] that they meet the criteria stated in Section 1.05 A. of this specification to be considered an acceptable tank builder.
2. A complete qualification package shall be submitted to the Engineer with their bid. The qualification submittal shall include the following items:

    a. Company's last two years financial reports or Balance Sheets and Profit and Loss Statements.
    b. Copy of fully documented Quality Assurance Program.
    c. Company personnel report indicating the following:
        i. Total number of employees by class (Superintendents, Tank builders, Nozzlemen, and Laborers) currently employed.
        ii. Number of employees, by class, available for project.
        iii. Number of anticipated temporary employees or new hires to be employed on project.
    d. Complete experience record for the tanks used to meet the experience requirement of Section 1.05 A. of this specification that have been designed and built in the tank construction company's own name. The record shall include the size of the tank, name, address and telephone number of the Owner, the year of construction and the name and telephone number of the Engineer for the project.
    e. Construction schedule which details the duration for tank construction.
3. The following are acceptable tank construction companies:
    a. The Crom Corporation, Gainesville, Florida.
    b. Precon Corporation, Newberry, Florida[ADD1]

1.06 WARRANTY

A. Provide a warranty document for workmanship and materials on the complete structural portion of the tank for a five-year period from the date of acceptance of the work. In case leakage or other defects appear within the five-year period, the tank construction company shall promptly repair the tank at its own expense upon written notice by the Owner that such defects have been found. Leakage is defined as a stream flow of liquid appearing on the exterior of the tank, the source of which is from the inside of the tank. The tank construction company shall not be responsible for, nor liable for, any subsurface condition. This warranty shall not apply to any accessory, equipment or product that is not a structural part of the tank and is manufactured by a company other than the tank construction company.

1.07 DESIGN CRITERIA

A. The design shall be in conformance with applicable portions of American Concrete Institute (ACI) 372R-03 Design and Construction of Circular Wire- and Strand-Wrapped Prestressed Concrete Structures, AWWA D110-04 Wire- and Strand-Wound, Circular, Prestressed Concrete Water Tanks, and currently accepted engineering principles and practices for the design of such structures.

B. The following loadings shall be utilized in the design:

1. Capacity: 22,000,000 Gallons
2. Dimensions: 260'0" Inside Diameter
3. Fluid Loads: Shall be the weight of all liquid when the reservoir is filled to capacity. The unit weight of the liquid material shall be 62.4 lbs/ft^3.
4. Roof Live Loads for Future Dome: The tank shall be designed for installation of a future concrete dome and consideration shall be given to all applicable roof design loads in accordance with AWWA D110, Section 3.3 and ASCE 7. The minimum roof live load for the ~~future~~ADD4 dome structure shall be 30 psf.
5. Dead Loads: Consideration shall be given to all permanent imposed loads including concrete and steel. The tank wall and footing shall be designed to accommodate the addition of a future concrete dome.
6. Seismic Loads: Seismic load shall be calculated using the effective mass procedure as specified in AWWA D110.
7. Soil Pressure: Earth loads shall be determined by rational methods of soil mechanics. Soil pressure shall not be used in the design of the core wall to counteract hydraulic loads or provide residual compression in the wall.
8. Differential Backfill Loads: Forces from differential backfill loads shall be considered in the design and shall be based on the at-rest coefficient. Passive resistance shall not be used to resist differential backfill loads.
9. Wind Loads: Wind loads shall be considered in the design in accordance with ASCE 7.
10. Seismic Load:
    a. Mapped Spectral Response Accelerations:
        i. Ss: 0.215g
        ii. S1: 0.089g
    b. Importance Factor: 1.25
    c. Site Classification: E

C. Pile Foundation: 48-inch diameter cased, drilled shafts, each with a 500-ton allowable compressive capacity. The design of the foundation for the prestressed concrete tank shall conform to the following:

1. Minimum pile embedment into the concrete structural floor shall be 3 inches.
2. Maximum tolerance for top elevation shall be - 0"/+ ½".

3. Minimum pile spacing tolerance shall be 6 inches.
4. Minimum spacing between shafts shall be 3 times the shaft diameter. In no case shall the spacing for the piles be greater than the following:
   a. Interior pile spacing: 15'-4"
   b. Perimeter pile spacing: 17'-0"
5. Alternate pile types or layouts may be considered for a deductive cost, including cost of structure and pile construction.

D. Structural Floor: The design of the floor for the prestressed concrete tank shall conform to the following:

1. The tank builder shall not deviate from the design presented herein without written approval of the ENGINEER.
2. Concrete structural floor shall contain a minimum reinforcing steel amount equal to 0.50% of the gross cross sectional area. Reinforcing steel shall be placed orthogonally and distributed with at least 2/3 of the total minimum area required in the top face and 1/3 of the total minimum area in the bottom face.
3. Concrete sections that are 24-inches or greater in thickness may have the minimum percentage of reinforcing based on a 12 inch concrete layer at each face.
4. Minimum reinforcing bar size shall be #4 bar.
5. Maximum spacing of reinforcing steel for the structural floor shall be 12 inches.
6. Concrete structural floor shall be designed to resist bending moments and shears induced by loadings required in Section 1.07 B. Moments and shears shall be calculated based on rational analysis utilizing an influence area derived from the pile spacing plus 2 times the pile spacing tolerance specified in Section 1.07 C3. In no case shall the dimensions and reinforcing steel for the concrete structural floor be less than the following:
   a. Minimum floor thickness: 32"
   b. Minimum top reinforcing steel: #6 at 4 3/4"
   c. Minimum bottom reinforcing steel: #5 at 7 1/4"
7. Circumferential steel shall be added to the outside edge of the structural floor as required to resist calculated bending moments in spans between perimeter piles. Circumferential steel required for bending moments shall be calculated by any rational one-way analysis with a minimum required amount of 0.75% placed in a minimum width of 4'-9". Minimum circumferential steel shall be distributed with 2/3 of the total area in the top face and 1/3 in the bottom face.
8. Radial steel shall be added to the top and bottom mats of reinforcing steel at the edge of the structural floor to account for edge effects in the circular plate. Edge effects shall include moments at the mid-span of the outer most span and the outside face of the first interior support of a two-way slab and shall be calculated by any rational analysis which considers these effects, but in no case shall be less than:
   a. Top radial bar: #6 at 9.5" c/c x 24' 5 3/4" long at 134'-1" radius
   b. Bottom radial bar: #5 at 7 1/4" c/c x 19' 5"9" long at 134'-1" radius

E. DOME

1. The dome roof shall be constructed of reinforced concrete and shall be circumferentially prestressed.
2. Dome shell reinforcement shall consist of reinforcing bars or welded wire fabric, not galvanized. Bolsters for wire fabric and reinforcing bars shall be plastic. Wire ties shall be galvanized.
3. The dome ring girder shall be prestressed with sufficient wire to withstand the dome dead load and design live loads. The ring girder shall have cross section suitable to accept the applied prestressing forces.
4. The high water level in the tank shall be permitted to encroach on the dome shell no higher than the upper horizontal plane of the dome ring girder.
5. Overflow outlets or the overflow pipe shall be capable of providing an overflow open area three times the area of the largest influent pipe.

6. Overflow outlets plus the dome ventilator shall be capable of providing an open area three times the area of the largest pipe.

7. The dome shall be designed as a free-span, spherical thin shell with one-tenth rise in accordance with the following:

   a. Typical Dome Design: The typical dome thickness and steel reinforcement shall meet the requirements of ANSI/AWWA D110.

   b. In all cases, the thickness of the dome shall be no less than 3 in.

   c. Dome Edge Design: The dome edge and upper wall shall be designed to resist the moments, thrusts, and shears that occur in this region due to dome and wall prestressing and loading conditions. The design of the edge region shall conform to the following:

      (1) Dome Edge Thickness:

         (a) A determination of the buckle diameter shall be made, as defined by:

$$d_b = 2.5 \cdot \sqrt{r_d \cdot t_d}$$ rounded up to the next foot

Where: d_b = buckle diameter in feet

r_d = dome radius in feet

t_d = typical dome thickness in feet

         (b) Dome edge thickening shall begin at a radial location on the dome, defined as s_2 which is at least one buckle diameter away from the tank wall.

         (c) A springline haunch shall be provided, which extends radially from the inside face of the tank wall to radial location s_1 which is defined as:

$$s_1 = 0.6 \cdot \sqrt{1.5 \cdot r_d \cdot t_d}$$ rounded up to the next foot

Where: s_1 = distance from inside face of wall to haunch in feet

s_2 = distance from inside face of wall to typical dome thickness in feet

This springline haunch shall begin at the inside face of the tank wall with a springline thickness as required by paragraph (f) below and shall end at radial location s_1 with the following thickness:

$$t_{d1} = 1.33 \cdot t_d$$

Where: t_{d1} = minimum thickness at s_1 in feet

t_d = typical dome thickness in feet at one buckle diameter from tank wall

         (d) Beginning at s_1 and continuing to s_2 the dome shell shall have a uniform straight line taper.

         (e) Parameters (b), (c), and (d) above are not required for domes where the calculated typical dome thickness is less than 75% of the actual typical dome thickness.

         (f) Sufficient concrete thickness at the springline of the dome shall be provided so that no more than 2 ft of the springline haunch is considered in calculating the effective dome edge ring cross sectional area. Compressive stress in this area shall not exceed 1000

psi when subjected to initial prestressing, offset by dead load only.

(2) Dome Edge Steel Reinforcement:

(a) Throughout the dome edge, the percentage of steel reinforcement, both radially and circumferentially, shall be no less than 0.25% of the gross cross sectional area of concrete.

(b) Along the dome edge, steel reinforcement shall be distributed between the upper and lower layers unless finite element analysis calculations indicate that tensile stress does not exist in the concrete along the bottom face of the dome edge. In that case, only top bars are required radially and circumferentially. In addition, radial and circumferential reinforcing bars will not be required along the bottom face of the dome edge where the calculated typical dome thickness is less than 75% of the actual typical dome thickness.

(c) Where reinforcing bars are required in the bottom layer, they shall be placed near the tank wall to insure adequate development at the intersection between dome and wall.

(d) In all cases, the percentage of circumferential steel reinforcement in the effective dome ring shall be no less than one percent of the gross cross sectional area of concrete. The effective dome ring is defined as ¼ of the haunch length not to exceed 2 ft.

(e) Where bottom dome edge steel reinforcement is required, vertical steel reinforcement along the inside face of the tank wall shall be no less than 0.5% of the cross sectional area of wall shotcrete.

F. Core wall:

1. The wire-wound, prestressed concrete tank core wall shall be designed as a thin shell cylindrical element using shotcrete and an embedded, mechanically bonded, steel shell diaphragm.
2. The design of the core wall shall take into account appropriate edge restraint. To compensate for bending moments, shrinkage, differential drying, and temperature stresses, the following minimum reinforcing steel shall be incorporated into the design:
   a. The top 2' of core wall shall have not less than 1% circumferential reinforcing.
   b. The bottom 3' of core wall shall have not less than 1% circumferential reinforcing.
   c. Inside Face:
      (1) The inside face of the core wall shall utilize the 26 gauge steel shell diaphragm as effective reinforcing.
      (2) Additional vertical and horizontal reinforcing steel bars shall be used as required by design computations.
   d. Outside Face:
      (1) Vertical reinforcing steel in the outside face of the core wall shall be: minimum of #4 bars at 12" center to center.
      (2) Additional vertical and horizontal reinforcing steel bars shall be used as required by design computations.
3. The minimum core wall thickness shall be 3½".
4. Backfill loads shall not be used in the design of the core wall to counteract hydraulic loads or provide residual compression in the wall.

5. Reinforcing steel used in the core wall shall be designed using a maximum allowable design tensile stress, f_s, of 18,000 psi.
6. Allowable compressive stress in the core wall due to initial prestressing force, f_{gi}, shall be:
   a. 1250 psi + 75t psi/in. with 0.5 f'_{gi} maximum or less (where f'_{gi} is defined as compressive strength at time initial prestressing force is applied and *t* is the thickness of the core wall in inches).
   b. Maximum of 2000 psi.
7. Allowable compressive stress in the core wall due to final prestressing force, f_g, shall be:
   a. 1250 psi + 75t psi/in. with 0.45 f'_g maximum (where f'_g is defined as compressive strength required for final prestressing force and *t* is the thickness of the core wall in inches).
   b. Maximum of 1800 psi.

G. Prestressing:

1. Circumferential prestressing of the tank shall be achieved by the application of cold-drawn, high-carbon steel wire complying with ASTM A 821 Type B, placed under high tension.
2. A substantial allowance shall be made for prestressing losses due to shrinkage and plastic flow in the shotcrete and due to relaxation in the prestressing steel.
3. The prestressing design shall conform to the following minimum requirements:
   a. Working stress for the tank wall, fs, shall be a maximum of 115,000 psi.
   b. The allowable design tensile stress in the prestressing wire before losses, fsi shall be 145,600 psi or no greater than 0.63 fu, where fu is defined as the ultimate strength of the wire.
   c. Areas to be prestressed will contain not fewer than 10 wires per foot of wall for 8 gauge and 8 wires per foot of wall for 6 gauge.
   d. A maximum of 24 wires per layer per foot for 8 gauge and 20 wires per layer per foot for 6 gauge will be allowed.

H. Wall Openings:

1. When it is necessary for a pipe to pass through the tank wall, the invert of such pipe or sleeve shall be no less than 18" above the floor slab, and the prestressing wires required at the pipe elevation shall be distributed above and below the opening leaving an unbanded strip around the entire tank.
2. Unbanded strips shall have a vertical dimension of no more than 36" unless an axi-symmetric shell analysis is performed to account for compressive forces plus shear and moments caused by displacement of the prestressing wires into adjacent bands.

PART 2 PRODUCTS

2.01 PERFORMANCE

A. Performance of the materials used in the tank construction shall conform to the minimum requirements of this specification.

B. Substitutions to the materials in this specification may only be made if submitted in writing and approved by the Engineer.

2.02 CONCRETE

A. Concrete shall conform to ACI 301.

B. All concrete shall utilize Type I/II Portland cement.

C. A maximum of 25% of cementitious material may be fly ash. ASTM C618 Class F with a LOI of 4% maximum.

D. Admixtures other than air-entraining and water reducing admixtures will not be permitted unless approved by the Engineer.

E. Coarse and fine aggregate shall meet the requirements of ASTM C 33.

F. Concrete mixes used in the construction of the tank shall conform to the following:

Mix	Compressive Strength (psi)	Minimum Cement Content (lbs)	Maximum Aggregate Size (in)	Maximum W/C Ratio	Air Content (%)	Slump (in)
Floor	4,500	564	¾	0.45	5% +/- 1%	4"+/-1"
Dome	4,500	600	3/8	0.45	5% +/- 1%	4"+/-1"

2.03 SHOTCRETE

A. Shotcrete shall conform to the requirements of ACI 506.2 except as modified herein.

B. All shotcrete mixes shall utilize Type I/II cement.

C. A maximum of 25% of cementitious material may be fly ash. ASTM C618 Class F with a LOI of 4% maximum.

D. All shotcrete in contact with diaphragm or prestressing wire shall be proportioned to consist of not more than three parts sand to one part Portland cement by weight. All other shotcrete shall be proportioned to consist of not more than four parts sand to one part Portland cement by weight.

E. Admixtures shall not contain more than trace amounts of chlorides, fluorides, sulfides or nitrates.

F. Shotcrete mixes used in the tank construction shall conform to the following:

Mix	Compressive Strength (psi)	Maximum W/C Ratio	Air Content (%)	Slump (in)	Fiber Reinforcement (lbs/cyd)
Core Wall	4,500	0.42	5% +/- 1%	4"+/-1"	-
Covercoat	4,500	0.42	5% +/- 1%	4"+/-1"	

2.04 PRESTRESSED REINFORCEMENT

A. The prestressing wire shall conform to the requirements of ASTM A 821, Type B.

B. The prestressing wire size shall be 0.162" (8 gauge), 0.192" (6 gauge) or larger, but no larger than 0.250".

C. The ultimate tensile strength, fu shall be, 231,000 psi or greater for 8 gauge wire, 222,000 psi or greater for 6 gauge.

2.05 NON-PRESTRESSED REINFORCEMENT

A. Non-prestressed mild reinforcing steel shall be new billet steel meeting the requirements of ASTM A 615 with a minimum yield strength, f_y, of 60,000 psi.

B. Welded wire reinforcing shall be plain wire conforming to the requirements of ASTM A 185 with a minimum yield strength, f_y, of 65,000 psi.

2.06 GALVANIZED STEEL DIAPHRAGM

A. The galvanized steel diaphragm used in the construction of the core wall shall be 26 gauge with a minimum thickness of 0.017 in. conforming to the requirements of ASTM A653/A653M. Weight of zinc coating shall be not less than G90 of Table 1 of ASTM A653/A653M.

B. The diaphragm shall be formed with re-entrant angles and erected so that a mechanical key is created between the shotcrete and diaphragm.

C. The diaphragm shall be continuous to within 3 inches of the top and bottom of the wall. Horizontal joints or splices will not be permitted.

D. All vertical joints in the diaphragm shall be rolled seamed, crimped, and sealed watertight using epoxy injection.

E. In all tanks designed to use a waterstop at the floor/wall joint, the steel shell diaphragm shall be epoxy bonded to the waterstop.

2.07 PVC WATERSTOPS, BEARING PADS AND SPONGE FILLER

A. Plastic waterstops shall be extruded from an elastomeric plastic material of which the base resin is virgin polyvinyl chloride.

B. The profile and size of the waterstop shall be suitable for the hydrostatic pressure and movements to which it is exposed.

C. Bearing pads used in floor/wall joints shall consist of neoprene, natural rubber or polyvinyl chloride.

D. Sponge filler at the floor/wall joint shall be closed-cell neoprene.

2.08 EPOXY

A. Epoxy Sealants:

1. Epoxy used for sealing the steel shell shall conform to the requirements of ASTM C 881.
2. Epoxy used for sealing the steel shell shall be, Type III, Grade 1, and shall be a 100% solids, moisture insensitive, low modulus epoxy system.
3. When pumped, maximum viscosity of the epoxy shall be 10 poises at 77°F.
4. The epoxy sealants used in the tank construction shall be suitable for bonding to concrete, shotcrete, PVC and steel.

B. Bonding Epoxy:

1. Epoxy resins used for enhancing the bond between fresh concrete and hardened concrete shall conform to the requirements of ASTM C 881.

2. Epoxy resins shall be a two-component, 100% solids, moisture-insensitive epoxy and shall be Type II, Grade 2.

2.09 SEISMIC RESTRAINT CABLES

A. When required by design, seismic restraint cables shall be seven-wire strand conforming to ASTM A 416.

B. The strand shall be protected with a fusion-bonded, grit-impregnated epoxy coating conforming to ASTM A 882.

C. The minimum yield strength of the seven-wire strand shall be 270,000 psi.

2.10 TANK ACCESSORIES

A. Access manhole: Minimum of ~~three~~ *six (6)*[ADD#1] Type 316 stainless steel wall manholes – ~~two 1'5" x 4'4: rectangular manholes and one 2'9" x 4'5½" rectangular dog hatch manhole~~ *52" x 24" rectangular wall manholes with hinged cover*[ADD#1]– for access to the interior of the tank. The cover and all hardware shall also be of Type 316 stainless steel. The wall manhole shall be designed to resist hydraulic loading without excessive deflection.

B. Exterior ~~Spiral Staircase~~ *Aluminum Ladder*[ADD#1]: One exterior ~~spiral staircase~~ *aluminum ladder*[ADD#1] shall be provided. The ~~staircase~~ *ladder*[ADD#1] shall be fabricated from 6061-T6 and 6063-T6 aluminum (mill finished) with Type 316 stainless steel fasteners and shall conform with all applicable OSHA standards. Acceptable manufacturer: Duvinage, LLC (or equal), 60 West Oak Ridge Drive, Hagerstown, MD 21741-0828. Toll Free Tel: 800-541-2645; Tel: 301-733-8255; Email: info@duvinage.com; Web: www.duvinage.com. ~~Spiral staircase~~ *Aluminum Ladder*[ADD#1] is not to be provided by the Tank Contactor.

C. Exterior aluminum platform with a minimum ~~3'0" x 4'0"~~ *4'0" x 6'0"*[ADD#1] area shall be provided at exterior ~~staircase~~ *ladder*[ADD#1] location. Platforms shall be fabricated from 6061-T6 aluminum with Type 316 stainless steel fasteners.

D. All other personnel access devices and platforms shall conform to the applicable OSHA standards.

E. Pipe brackets: Pipe brackets shall be provided in quantities and locations shown in the plans and shall be fabricated from 316 stainless steel with 316 stainless steel fasteners.

2.11 COATINGS

A. Exterior coating system shall consist of the following:

1. No exterior or interior coatings required.

PART 3 EXECUTION

3.01 EXAMINATION

A. All subgrade elevations shall be verified prior to starting tank construction.

3.02 INSTALLATION

A. Floor:

1. The subgrade shall be prepared by fine grading to ensure proper placement of reinforcing steel with proper bottom cover.
2. A 10-mil polyethylene vapor-barrier shall be placed after subgrade preparation has been completed.
3. Form and screed boards shall be of proper thickness and sufficiently braced to ensure that the floor is constructed within proper thickness tolerances.
4. Sand pads shall be used to support reinforcing steel in the construction of the floor to ensure positive control of placement of reinforcing steel.
5. The floor shall be vibratory screeded to effect consolidation of concrete and proper encasement of floor reinforcing steel.
6. The floor shall be continuously water cured until tank construction is completed.
7. The floor shall receive a fine broom finish.

B. Core Wall:

1. The wall shall be constructed in a predesigned manner utilizing steel shell diaphragm, layers of shotcrete and prestressing wire with each conforming to the following:

   a. Diaphragm Erection:
      (1) The diaphragm shall be protected against damage before, during, and after erection. Nail or other holes shall not be made in the steel shell for erection or other purposes except for inserting wall pipes or sleeves, reinforcing steel, bolts, or other special appurtenances. Such penetrations shall be sealed with an epoxy sealant which complies with Section 2.08 Epoxy.

   b. Shotcrete:
      (1) All shotcrete shall be applied by or under direct supervision of experienced nozzlemen certified by the American Concrete Institute (ACI) as outlined in ACI certification publication CP-60.
      (2) Each shotcrete layer shall be broomed prior to final set to effect satisfactory bonding of the following layer.
      (3) No shotcrete shall be applied to reinforcing steel or diaphragm that is encrusted with overspray.
      (4) No less than ⅛" thick shotcrete shall separate reinforcing steel and prestressing wire.
      (5) The steel shell diaphragm shall be encased and protected with no less than 1" of shotcrete in all locations.

   c. Curing:
      (1) Interior and exterior portions of the shotcrete wall shall be water cured for a minimum of 7 days or until prestressing is started.

C. Epoxy Injection:

1. Epoxy injection shall be carried out from bottom to top of wall using a pressure pumping procedure.
2. Epoxy injection shall proceed only after the steel shell has been fully encased, inside and outside, with shotcrete.

D. Dome:

1. All concrete shall be consolidated by means of a vibrator for proper encasement of reinforcing steel and welded wire fabric.

2. All surfaces at the joint between the wall and the dome shall be coated with bonding epoxy which complies with Section 2.08 Epoxy.
3. Plastic bolsters shall be used to support reinforcing steel and welded wire reinforcement to ensure positive control on placement of steel.
4. The exterior surface of the dome shall receive a fine broom finish.
5. The dome shall be water cured for a minimum 7 days after casting or until dome band prestressing is completed.

E. Prestressing:

1. The initial tension in each wire shall be read and recorded to verify that the total aggregate force is no less than that required by the design. Averaging or estimating the force of the wire on the wall shall not be considered satisfactory evidence of correct placement of prestressing wires.
2. Placement of the prestressing steel wire shall be in a continuous and uniform helix of such pitch as to provide in each lineal foot of core wall height an initial force and unit compressive force equal to that shown on the design drawings. Splicing of the wire shall be permitted only when completing the application of a full coil of wire or when removing a defective section of wire.
3. Shotcrete shall be used to completely encase each individual wire and to protect it from corrosion. To facilitate this encasement, the clear space between adjacent wires is to be no less than one wire diameter.
4. Prestressing shall be accomplished by a machine capable of continuously inducing a uniform initial tension in the wire before it is positioned on the tank wall. Tension in the wire shall be generated by methods not dependent on cold working or re-drawing of the wire. In determining compliance with design requirements, the aggregate force of all tensioned wires per foot of wall shall be considered rather than the force per individual wire, and such aggregate force shall be no less than that required by the design and as shown on approved drawings.
5. The tank construction company shall supply equipment at the construction site to measure tension in the wire after it is positioned on the tank wall. The stress measuring equipment shall include: electronic direct reading stressometer accurate to within 2%, calibrated dynamometers and a test stand to verify the accuracy of the equipment.
6. After circumferential prestressing wires have been placed, they shall be protected by encasement in shotcrete. This encasement shall completely encapsulate each wire and permanently bond the wire to the tank wall.
7. When multiple layers of wire are required, shotcrete cover between layers shall be no less than ⅛" thick.

F. Covercoat:

1. After all circumferential prestressing wires have been placed, a shotcrete cover having a thickness of no less than 1" shall be placed over the prestressing wires.
2. Horizontal sections of the wall shall form true circles without flat areas, excessive bumps or hollows.
3. The covercoat shall receive a sliced trowel finish.

G. Wall Openings:

1. All wall pipes, sleeves and manholes passing through the wall shall be sealed to the steel shell diaphragm by epoxy injection.

3.03 FIELD QUALITY CONTROL

A. Inspection and Testing

1. Concrete and Shotcrete Testing:

a. Compression Tests:
   (1) Compression test specimens shall be taken during construction from the first placement of each class of concrete specified herein and at intervals thereafter as selected by the Engineer to insure continued compliance with these Specifications. At least one set of test specimens shall be made for each 100 cubic yards of concrete/shotcrete placed. Each set of test specimens shall be a minimum of 5 cylinders.
   (2) Compression test specimens for concrete/shotcrete shall conform to ASTM C 172 for sampling and ASTM C 31 for making and curing test cylinders. Test specimens shall be 6-inch diameter by 12-inch high or 4-inch diameter by 8-inch high cylinders.
   (3) Compression test shall be performed in accordance with ASTM C 39. Two test cylinders will be tested at 7 days and two at 28 days. The remaining cylinder will be held to verify test results, if needed.

b. Air Content Tests:
   (1) Air content tests shall conform to ASTM C 231 (Pressure Method for Air Content).
   (2) Tests for air content shall be made prior to concrete placement and whenever compression test specimens are made.
   (3) No air testing shall be conducted on the shotcrete.

c. Slump Tests:
   (1) Slump tests shall be made in accordance with ASTM C 143.
   (2) Slump tests shall be made whenever compression test specimens are made.
   (3) No slump testing shall be conducted on the shotcrete. *ADD4*

d. Shotcrete and Concrete Testing:
   (1) All shotcrete and concrete testing shall be paid for by the Owner, with exception to testing required for defective work. *ADD#5*

2. Hydrostatic Testing: **(To be performed by the tank contractor and included in the lump sum cost of the tank)**

a. On completion of the tank and prior to any specified backfill placement at the footing or wall, the tank shall be tested for watertightness.
b. The testing for watertightness shall be completed as follows:
   (1) Test the floor waterstop connection with air pressure and soapy water to determine if leaks are present.
   (2) If no leaks are found in test item No. 1 fill the tank with water to a depth of 1'-0" above the sidewall access and let it stand for a minimum of 24 hours.
   (3) Inspect the exterior of the tank wall and footing for damp spots. Damp spots shall be defined as spots where moisture can be picked up on a dry hand, the source of which is from inside the tank.
   (4) Leakage through the wall or wall-base joint shall be repaired and the tank shall be retested using the above procedure.
   (5) Non-potable water shall be utilized for the test. Wastewater is not allowed.

3.04 CLEANING

A. The interior of the tank shall be cleaned to remove debris, construction items, and equipment prior to testing.

END OF SECTION

DIVISION 15

MECHANICAL

SECTION 15195 - FACILITY NATURAL-GAS PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:

1. Pipes, tubes, and fittings.
2. Piping specialties.
3. Piping and tubing joining materials.
4. Valves.
5. Pressure regulators.

1.03 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of the following:

1. Piping specialties.
2. Corrugated, stainless-steel tubing with associated components.
3. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
4. Pressure regulators. Indicate pressure ratings and capacities.
5. Dielectric fittings.

B. Shop Drawings: For facility natural-gas piping layout. Include plans, piping layout and elevations, sections, and details for fabrication of pipe anchors, hangers, supports for multiple

pipes, alignment guides, expansion joints and loops, and attachments of the same to building structure. Detail location of anchors, alignment guides, and expansion joints and loops.

1. Detail mounting, supports, and valve arrangements for service meter assembly and pressure regulator assembly.

1.05 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans and details, drawn to scale, on which natural-gas piping is shown and coordinated with other installations, using input from installers of the items involved.

B. Site Survey: Plans, drawn to scale, on which natural-gas piping is shown and coordinated with other services and utilities.

C. Qualification Data: For qualified professional engineer.

D. Welding certificates.

E. Field quality-control reports.

1.06 QUALITY ASSURANCE

A. Steel Support Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Handling Flammable Liquids: Remove and dispose of liquids from existing natural-gas piping according to requirements of authorities having jurisdiction.

B. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

C. Store and handle pipes and tubes having factory-applied protective coatings to avoid damaging coating, and protect from direct sunlight.

D. Protect stored PE pipes and valves from direct sunlight.

1.08 PROJECT CONDITIONS

A. Perform site survey, research public utility records, and verify existing utility locations. Contact utility-locating service for area where Project is located.

B. Interruption of Existing Natural-Gas Service: Do not interrupt natural-gas service to facilities occupied by Owner or others unless permitted under the following conditions and then only

after arranging to provide purging and startup of natural-gas supply according to requirements indicated:

1. Notify Construction Manager no fewer than two days in advance of proposed interruption of natural-gas service.

1.09 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

B. Coordinate requirements for access panels and doors for valves installed concealed behind finished surfaces. Comply with requirements in Section 08311 "Access Doors and Frames."

PART 2 - PRODUCTS

2.01 PIPES, TUBES, AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.

1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.

2. Wrought-Steel Welding Fittings: ASTM A 234/A 234M for butt welding and socket welding.

3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.

4. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

   a. Material Group: 1.1.

   b. End Connections: Threaded or butt welding to match pipe.

   c. Lapped Face: Not permitted underground.

   d. Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.

   e. Bolts and Nuts: ASME B18.2.1, carbon steel aboveground and stainless steel underground.

5. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.

   a. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.

6. Mechanical Couplings:

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

      1) Dresser Piping Specialties; Division of Dresser, Inc.

2) Smith-Blair, Inc.

3) Approved equal.

b. Steel flanges and tube with epoxy finish.

c. Buna-nitrile seals.

d. Steel bolts, washers, and nuts.

e. Coupling shall be capable of joining PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.

f. Steel body couplings installed underground on plastic pipe shall be factory equipped with anode.

B. Corrugated, Stainless-Steel Tubing: Comply with ANSI/IAS LC 1.

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

a. OmegaFlex, Inc.

b. Parker Hannifin Corporation; Parflex Division.

c. Titeflex.

d. Tru-Flex Metal Hose Corp.

2. Tubing: ASTM A 240/A 240M, corrugated, Series 300 stainless steel.

3. Coating: PE with flame retardant.

a. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1) Flame-Spread Index: 25 or less.

2) Smoke-Developed Index: 50 or less.

4. Fittings: Copper-alloy mechanical fittings with ends made to fit and listed for use with corrugated stainless-steel tubing and capable of metal-to-metal seal without gaskets. Include brazing socket or threaded ends complying with ASME B1.20.1.

5. Striker Plates: Steel, designed to protect tubing from penetrations.

6. Manifolds: Malleable iron or steel with factory-applied protective coating. Threaded connections shall comply with ASME B1.20.1 for pipe inlet and corrugated tubing outlets.

7. Operating-Pressure Rating: 5 psig (34.5 kPa).

C. PE Pipe: ASTM D 2513, SDR 11.

1. PE Fittings: ASTM D 2683, socket-fusion type of ASTM D 3261, butt-fusion type with dimensions matching PE pipe.

2. PE Transition Fittings: Factory-fabricated fittings with PE pipe complying with ASTM D 2513, SDR 11; and steel pipe complying with ASTM A 53/a 53m, BLACK STEEL, Schedule 40, Type E or S, Grade B.

3. Anodeless Service-Line Risers: Factory fabricated and leak tested.

   a. Underground Portion: PE pipe complying with ASTM D 2513, SDR 11 inlet.

   b. Casing: Steel pipe complying with ASTM A 53/a 53M, Schedule 40, black steel, Type E or S, Grade B, with corrosion-protective coating covering.

   c. Aboveground Portion: PE transition fitting.

   d. Outlet shall be threaded or flanged or suitable for welded connection.

   e. Tracer wire connection.

   f. Ultraviolet shield.

   g. Stake supports with factory finish to match steel pipe casing or carrier pipe.

4. Transition Service-Line Risers: Factory fabricated and leak tested.

   a. Underground Portion: PE pipe complying with ASTM D 2513, SDR 11 inlet connected to steel pipe complying with ASTM A 53/A 53M, Schedule 40, Type E or S, Grade B, with corrosion-protective coating for aboveground outlet.

   b. Outlet shall be threaded or flanged or suitable for welded connection.

   c. Bridging sleeve over mechanical coupling.

   d. Factory-connected anode.

   e. Tracer wire connection.

   f. Ultraviolet shield.

   g. Stake supports with factory finish to match steel pipe casing or carrier pipe.

5. Plastic Mechanical Couplings, NPS 1-1/2 (DN 40) and Smaller: Capable of joining PE pipe to PE pipe.

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

      1) Lyall, R. W. & Company, Inc.

      2) Mueller Co.; Gas Products Div.

      3) Perfection Corporation; a subsidiary of American Meter Company.

   b. PE body with molded-in, stainless-steel support ring.

   c. Buna-nitrile seals.

   d. Acetal collets.

   e. Electro-zinc-plated steel stiffener.

6. Plastic Mechanical Couplings, NPS (DN 50) and Larger: Capable of joining PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.

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

        1) Lyall, R.W. & Company, Inc.

        2) Mueller Co.; Gas products Div.

        3) Perfection Corporation; a subsidiary of American Meter Company.

    b. Fiber-reinforced plastic body.

    c. PE body tube.

    d. Buna-nitrile seals.

    e. Acetal collets.

    f. Stainless-steel bolts, nuts, and washers.

7. Steel Mechanical Couplings: Capable of joining plain-end PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.

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

        1) Dresser Piping Specialties; Division of Dresser, Inc.

        2) Smith-Blair, Inc.

    b. Stainless-steel flanges and tube with epoxy finish.

    c. Buna-nitrile seals.

    d. Stainless-steel bolts, washers, and nuts.

    e. Factory-installed anode for steel-body couplings installed underground.

2.02 CONTAINMENT CONDUIT

A. PVC Pipe

1. Solid Wall PVC Pipe: ASTM D2665.

2. Cellular Core PVC Pipe: ASTM F891, Schedule 40.

2.03 PIPING SPECIALTIES

A. Appliance Flexible Connectors:

1. Indoor, Fixed-Appliance Flexible Connectors: Comply with ANSI Z21.24.

2. Indoor, Movable-Appliance Flexible Connectors: Comply with ANSI Z21.69.

3. Outdoor, Appliance Flexible Connectors: Comply with ANSI Z21.75.

4. Corrugated stainless-steel tubing with polymer coating.

5. Operating-Pressure Rating: 0.5 psig (3.45 kPa).

6. End Fittings: Zinc-coated steel.

7. Threaded Ends: Comply with ASME B1.20.1.

8. Maximum Length: 72 inches (1830 mm.)

B. Quick-Disconnect Devices: Comply with ANSI Z21.41.

1. Copper-alloy convenience outlet and matching plug connector.

2. Nitrile seals.

3. Hand operated with automatic shutoff when disconnected.

4. For indoor or outdoor applications.

5. Adjustable, retractable restraining cable.

C. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.

2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.

3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.

4. CWP Rating: 125 psig (862 kPa).

D. Basket Strainers:

1. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.

2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.

3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.

4. CWP Rating: 125 psig (862 kPa).

E. T-Pattern Strainers:

1. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.

2. End Connections: Grooved ends.

3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 57 percent free area.

4. CWP Rating: 750 psig (5170 kPa).

F. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

2.04 JOINING MATERIALS

A. Joint Compound and Tape: Suitable for natural gas.

B. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

C. Brazing Filler Metals: Alloy with melting point greater than 1000 deg F (540 deg C) complying with AWS A5.8/A5.8M. Brazing alloys containing more than 0.05 percent phosphorus are prohibited.

2.05 MANUAL GAS SHUTOFF VALVES

A. General Requirements for Metallic Valves, NPS 2 (DN 50) and Smaller: Comply with ASME B16.33.

1. CWP Rating: 125 psig (862 kPa).

2. Threaded Ends: Comply with ASME B1.20.1.

3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.

4. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.

5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch (25 mm) and smaller.

6. Service Mark: Valves 1-1/4 inches (32 mm) to NPS 2 (DN 50) shall have initials "WOG" permanently marked on valve body.

B. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.

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

a. BrassCraft Manufacturing Company; a Masco company.

b. Conbraco Industries, Inc.; Apollo Div.

c. Lyall, R. W. & Company, Inc.

d. McDonald, A. Y. Mfg. Co.

e. Perfection Corporation; a subsidiary of American Meter Company.

2. Body: Bronze, complying with ASTM B 584.

3. Ball: Chrome-plated bronze.

4. Stem: Bronze; blowout proof.

5. Seats: Reinforced TFE; blowout proof.

6. Packing: Threaded-body packnut design with adjustable-stem packing.

7. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.

8. CWP Rating: 600 psig (4140 kPa).

9. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.

10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

C. Two-Piece, Regular-Port Bronze Ball Valves with Bronze Trim: MSS SP-110.

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

   a. BrassCraft Manufacturing Company; a Masco company.

   b. Conbraco Industries, Inc.; Apollo Div.

   c. Lyall, R. W. & Company, Inc.

   d. McDonald, A. Y. Mfg. Co.

   e. Perfection Corporation; a subsidiary of American Meter Company.

2. Body: Bronze, complying with ASTM B 584.

3. Ball: Chrome-plated bronze.

4. Stem: Bronze; blowout proof.

5. Seats: Reinforced TFE; blowoff proof.

6. Packing: Threaded-body packnut design with adjustable-stem packing.

7. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.

8. CWP Rating: 600 psig (4140 kPa).

9. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.

10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

D. Cast-Iron, Lubricated Plug Valves: MSS SP-78.

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

   a. Flowserve.

b. Homestead Valve; a division of Olson Technologies, Inc.

c. McDonald, A. Y. Mfg. Co.

d. Milliken Valve Company.

e. Mueller Co.; Gas Products Div.

f. R&M Energy Systems, A Unit of Robbins & Myers, Inc.

2. Body: Cast iron, complying with ASTM A 126, Class B.

3. Plug: Bronze or nickel-plated cast iron.

4. Seat: Coated with thermoplastic.

5. Stem Seal: Compatible with natural gas.

6. Ends: Threaded or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.

7. Operator: Square head or lug type with tamperproof feature where indicated.

8. Pressure Class: 125 psig (862 kPa).

9. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.

10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

2.06 PRESSURE REGULATORS

A. General Requirements:

1. Single stage and suitable for natural gas.

2. Steel jacket and corrosion-resistant components.

3. Elevation compensator.

4. End Connections: Threaded for regulators NPS 2 (DN 50) and smaller; flanged for regulators NPS 2-1/2 (DN 65) and larger.

B. Service Pressure Regulators: Provided and set by natural gas piping installer.

C. Appliance Pressure Regulators: Comply with ANSI Z21.18.

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

a. Canadian Meter Company Inc.

b. Eaton Corporation; Controls Div.

c. Harper Wyman Co.

d. Maxitrol Company.

e. SCP, Inc.

2. Body and Diaphragm Case: Die-cast aluminum.

3. Springs: Zinc-plated steel; interchangeable.

4. Diaphragm Plate: Zinc-plated steel.

5. Seat Disc: Nitrile rubber.

6. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.

7. Factory-Applied Finish: Minimum three-layer polyester and polyurethane paint finish.

8. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.

9. Maximum Inlet Pressure: 1 psig (6.9 kPa).

2.07 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:

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

a. Capitol Manufacturing Company.

b. Central Plastics Company.

c. Hart Industries International, Inc.

d. Jomar International Ltd.

e. Matco-Norca, Inc.

f. McDonald, A. Y. Mfg. Co.

g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

h. Wilkins; a Zurn company.

2. Description:

a. Standard: ASSE 1079.

b. Pressure Rating: 125 psig (860 kPa) minimum at 180 deg F (82 deg C).

c. End Connections: Solder-joint copper alloy and threaded ferrous.

2.08 LABELING AND IDENTIFYING

A. Detectable Warning Tape: Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches (150 mm) wide and 4 mils (0.1 mm) thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches (750 mm) deep; colored yellow.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine roughing-in for natural-gas piping system to verify actual locations of piping connections before equipment installation.

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

3.02 PREPARATION

A. Close equipment shutoff valves before turning off natural gas to premises or piping section.

B. Inspect natural-gas piping according to NFPA 54 to determine that natural-gas utilization devices are turned off in piping section affected.

C. Comply with NFPA 54 requirements for prevention of accidental ignition.

3.03 OUTDOOR PIPING INSTALLATION

A. Comply with NFPA 54 for installation and purging of natural-gas piping.

B. Install underground, natural-gas piping buried at least 36 inches (900 mm) below finished grade. Comply with requirements in Section 02300 "Earthwork" for excavating, trenching, and backfilling.

1. If natural-gas piping is installed less than 36 inches (900 mm) below finished grade, install it in containment conduit.

C. Install underground, PE, natural-gas piping according to ASTM D 2774.

D. Steel Piping with Protective Coating:

1. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.

2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.

3. Replace pipe having damaged PE coating with new pipe.

E. Install fittings for changes in direction and branch connections.

3.04 INDOOR PIPING INSTALLATION

A. Comply with NFPA 54 for installation and purging of natural-gas piping.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.

D. Install piping exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Locate valves for easy access.

F. Install natural-gas piping at uniform grade of 2 percent down toward drip and sediment traps.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Verify final equipment locations for roughing-in.

J. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.

K. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.

1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches (75 mm) long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.

L. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.

M. Prohibited Locations:

1. Do not install natural-gas piping in or through circulating air ducts, clothes or trash chutes, chimneys, or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.

2. Do not install natual-gas piping in solid walls or partitions.

N. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

O. Connect branch piping from top or side of horizontal piping.

P. Install unions in pipes NPS 2 (DN 50) and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.

Q. Do not use natural-gas piping as grounding electrode.

R. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.

3.05 VALVE INSTALLATION

A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing, aluminum, or copper connector.

B. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

3.06 PIPING JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints:

1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.

2. Cut threads full and clean using sharp dies.

3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.

4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.

5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Flanged Joints: Install gasket material, size, type, and thickness appropriate for natural-gas service. Install gasket concentrically positioned.

E. Flared Joints: Cut tubing with roll cutting tool. Flare tube end with tool to result in flare dimensions complying with SAE J513. Tighten finger tight, then use wrench. Do not overtighten.

3.07 HANGER AND SUPPORT INSTALLATION

A. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 1 (DN 25) and Smaller: Maximum span, 96 inches (2438 mm); minimum rod size, 3/8 inch (10 mm).

2. NPS 1-1/4 (DN 32): Maximum span, 108 inches (2743 mm); minimum rod size, 3/8 inch (10 mm).

3. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): Maximum span, 108 inches (2743 mm); minimum rod size, 3/8 inch (10 mm).

4. NPS 2-1/2 to NPS 3-1/2 (DN 65 to DN 90): Maximum span, 10 feet (3 m); minimum rod size, 1/2 inch (13 mm).

B. Install hangers for horizontal, corrugated stainless-steel tubing with the following maximum spacing and minimum rod sizes:

1. NPS 3/8 (DN 10): Maximum span, 48 inches (1220 mm); minimum rod size, 3/8 inch (10 mm).

2. NPS 1/2 (DN 15): Maximum span, 72 inches (1830 mm); minimum rod size, 3/8 inch (10 mm).

3. NPS 3/4 (DN 20) and Larger: Maximum span, 96 inches (2440 mm); minimum rod size, 3/8 inch (10 mm).

3.08 CONNECTIONS

A. Connect to utility's gas main according to Columbia Natural Gas procedures and requirements.

B. Install natural-gas piping electrically continuous, and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.

C. Install piping adjacent to appliances to allow service and maintenance of appliances.

D. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches (1800 mm) of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.

E. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.09 LABELING AND IDENTIFYING

A. Install detectable warning tape directly above gas piping, 12 inches (300 mm) below finished grade, except 6 inches (150 mm) below subgrade under pavements and slabs.

3.10 PAINTING

A. Comply with requirements in Section 09911 "Exterior Painting" and Section 09912 "Interior Painting" for painting interior and exterior natural-gas piping.

B. Paint exposed, interior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory-applied paint or protective coating.

1. Latex Over Alkyd Primer System: MPI INT 5.1Q.

a. Prime Coat: Alkyd anticorrosive metal primer.

b. Intermediate Coat: Interior latex matching topcoat.

c. Topcoat: Interior latex (flat).

d. Color: Yellow.

C. Damage and Touchup: Repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.

3.11 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Test, inspect, and purge natural gas according to NFPA 54 and authorities having jurisdiction.

C. Natural-gas piping will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.12 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain earthquake valves.

3.13 OUTDOOR PIPING SCHEDULE

A. Underground natural-gas piping shall be one of the following:

1. PE pipe and fittings joined by heat fusion, or mechanical couplings; service-line risers with tracer wire terminated in an accessible location.

2. Steel pipe with wrought-steel fittings and welded joints, or mechanical couplings. Coat pipe and fittings with protective coating for steel piping.

3. Annealed-temper copper tube with wrought-copper fittings and brazed joints. Coat pipe and fittings with protective coating for copper tubing.

B. Aboveground natural-gas piping shall be one of the following:

1. Steel pipe with malleable-iron fittings and threaded joints.

2. Steel pipe with wrought-steel fittings and welded joints.

3. Annealed-temper copper tube with wrought-copper fittings and brazed joints.

C. Branch Piping in Cast-in-Place Concrete to Single Appliance: Annealed-temper copper tube with wrought-copper fittings and brazed joints. Install piping embedded in concrete with no joints in concrete.

D. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

3.14 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES LESS THAN 0.5 PSIG (3.45 kPa)

A. Aboveground, branch piping NPS 1 (DN 25) and smaller shall be one of the following:

1. Corrugated stainless-steel tubing with mechanical fittings having socket or threaded ends to match adjacent piping.

2. Steel pipe with malleable-iron fittings and threaded joints.

B. Aboveground, distribution piping shall be the following:

1. Steel pipe with malleable-iron fittings and threaded joints.

3.15 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES MORE THAN 0.5 PSIG (3.45 kPa) AND LESS THAN 5 PSIG (34.5 kPa)

A. Aboveground, branch piping shall be the following:

1. Steel pipe with malleable-iron fittings and threaded joints.

3.16 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

A. Valves for pipe sizes NPS 2 (DN 50) and smaller at service meter shall be the following:

1. Two-piece, full-port, bronze ball valves with bronze trim.

B. Distribution piping valves for pipe sizes NPS 2-1/2 (DN 65) and larger shall be the following:

1. Cast-iron, lubricated plug valve.

C. Valves in branch piping for single appliance shall be the following:

1. Two-piece, full-port, bronze ball valves with bronze trim.

END OF SECTION

SECTION 15838 - POWER VENTILATORS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:

1. Centrifugal upblast roof ventilators.

1.03 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base fan-performance ratings on actual Project site elevations.

B. Operating Limits: Classify according to AMCA 99.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Also include the following:

1. Certified fan performance curves with system operating conditions indicated.

2. Certified fan sound-power ratings.

3. Motor ratings and electrical characteristics, plus motor and electrical accessories.

4. Material thickness and finishes, including color charts.

5. Dampers, including housings, linkages, and operators.

6. Roof curbs.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

2. Wiring Diagrams: For power, signal, and control wiring.

C. Delegated-Design Submittal: For unit hangars and supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

2. Design Calculations: Calculate requirements for selecting vibration isolators and for designing vibration isolation bases.

1.05 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

1. Roof framing and support members relative to duct penetrations.

2. Ceiling suspension assembly members.

3. Size and location of initial access modules for acoustical tile.

4. Ceiling-mounted items including light fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

B. Field quality-control reports.

1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For power ventilators to include in emergency, operation, and maintenance manuals.

1.07 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1.08 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. AMCA Compliance: Fans shall have AMCA-Certified performance ratings and shall bear the AMCA-Certified Ratings Seal.

C. UL Standards: Power ventilators shall comply with UL 705. Power ventilators for use for restaurant kitchen exhaust shall also comply with UL 762.

1.09 COORDINATION

A. Coordinate size and location of structural-steel support members.

B. Coordinate sizes and locations of concrete bases with actual equipment provided.

C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

PART 2 - PRODUCTS

2.01 CENTRIFUGAL ROOF VENTILATORS

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

1. Acme Engineering & Manufacturing Corporation.
2. Aerovent; a division of Twin City Fan Companies, Ltd.
3. American Coolair Corporation.
4. Carnes Company.
5. Central Blower Company.
6. Greenheck Fan Corporation.
7. Hartzell Fan Incorporated.
8. Loren Cook Company.

B. Housing: Removable, spun-aluminum, dome top and outlet baffle; square, one-piece, aluminum base with venturi inlet cone.

1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains.
2. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.

C. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.

D. Belt Drives:

1. Resiliently mounted to housing.
2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
3. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
4. Pulleys: Cast-iron, adjustable-pitch motor pulley.
5. Fan and motor isolated from exhaust airstream.

E. Accessories:

1. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.
2. Bird Screens: Removable, 1/2-inch (13-mm) mesh, aluminum or brass wire.
3. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.

F. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch- (40-mm-) thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch (40-mm) wood nailer. Size as required to suit roof opening and fan base.

1. Configuration: Built-in raised cant and mounting flange.

2. Overall Height: 12 inches (300 mm).

3. Sound Curb: Curb with sound-absorbing insulation.

4. Pitch Mounting: Manufacture curb to match roof or deck.

5. Metal Liner: Galvanized steel.

6. Mounting Pedestal: Galvanized steel with removable access panel.

G. Capacities and Characteristics: See Schedule.

2.02 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 15 Section "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 16 Sections.

B. Enclosure Type: Totally enclosed, fan cooled.

2.03 SOURCE QUALITY CONTROL

A. Certify sound-power level ratings according to AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Certify fan performance ratings, including flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating." Label fans with the AMCA-Certified Ratings Seal.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install power ventilators level and plumb.

B. Secure roof-mounted fans to roof curbs with cadmium-plated hardware.

C. Ceiling Units: Suspend units from structure; use steel wire or metal straps.

D. Support suspended units from structure using threaded steel rods and spring hangers having a static deflection of 1 inch (25 mm).

E. Install units with clearances for service and maintenance.

3.02 CONNECTIONS

A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors.

B. Install ducts adjacent to power ventilators to allow service and maintenance.

C. Ground equipment according to Division 16 Section "Grounding and Bonding."

D. Connect wiring according to Division 16 Section "Conductors and Cables."

3.03 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. Verify that shipping, blocking, and bracing are removed.

2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.

3. Verify that cleaning and adjusting are complete.

4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.

5. Adjust belt tension.

6. Adjust damper linkages for proper damper operation.

7. Verify lubrication for bearings and other moving parts.

8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.

9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.

10. Shut unit down and reconnect automatic temperature-control operators.

11. Remove and replace malfunctioning units and retest as specified above.

C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Prepare test and inspection reports.

3.04 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Replace fan and motor pulleys as required to achieve design airflow.

D. Lubricate bearings.

END OF SECTION

DIVISION 16

ELECTRICAL

SECTION 16050 - BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.01 REQUIREMENT

A. Contractors bidding work under this Contract shall read and understand Division Zero and Division 1 - General Requirements. If any discrepancies are discovered between the Basic Electrical Materials and Methods and General Requirements, the above mentioned documents shall overrule this section. The Basic Electrical Materials and Methods are intended as a supplement to the above mentioned documents.

B. The Contractor shall bid as outlined in the above mentioned Specifications and shall be governed by any alternates or unit prices called for in the form of proposal.

C. Each Contractor bidding on the work included in these Specifications shall view the building site and carefully examine the contract Drawings and Specifications, so that he/she may fully understand what is to be done, and to document existing conditions.

1.02 SCOPE OF WORK

A. Work included in this section of the Specifications shall include the furnishing of all labor, material, tools, approvals, utility connection fees, excavation, backfill, and other equipment necessary to install the electrical system as shown on the Contract Drawings and as specified herein.

B. It also includes installation and connection of all electrical utilization equipment included in this Contract but furnished by other contractors or suppliers.

C. It is the general intent that all motors shall be furnished with the particular object of equipment it drives, except where a new motor is to be provided for an item of existing equipment (a replacement motor), then it shall be provided under this Division of the Specifications.

D. The Contractor shall furnish and install all conduit, wire, disconnect switches and miscellaneous material to make all electrical connections to all items of utilization equipment or wiring devices except as otherwise specified.

E. Equipment connections shall be made with flexible or rigid conduit as required. Controllers for motors, disconnect switches, and all control, protective and signal devices for motor circuits, except where such apparatus is furnished mounted and connected integrally with the motor driven equipment, shall be installed, connected and left in operating condition. The number and size of conductors between motors and control or protective apparatus shall be as required to obtain the operation described in these Specifications, and/or by the Contract Documents, and/or as shown in manufacturer furnished, Engineer reviewed Shop Drawings.

F. All devices and items of electrical equipment, including those shown on the Contract Drawings but not specifically mentioned in the Specifications or those mentioned in the Specifications but not shown on the Contract Drawings, are to be furnished under this section of the specifications. Any such device or item of equipment, if not defined in quality, shall be equal to similar Equipment and/or devices specified herein.

G. All devices and items of equipment mentioned in this section of the Specifications whether electrical or not or whether furnished under this or other Division of the Specifications, shall be installed under this Division of the Specifications, unless specifically indicated otherwise.

H. Where wiring diagrams are not shown on the Contract Drawings, they are to be provided by the supplier of the equipment served and such diagrams shall be adhered to except as herein modified.

I. The following is a list of items that may not be defined clearly on the Contract Drawings or in other parts of these Specifications. The list is meant to be an aid to the Contractor and is not necessarily a complete list of all work to be performed under this Contract:

1. Connect all motors and accessories furnished by equipment suppliers.
2. Furnish, install, and connect all motor controls.
3. Furnish, install, and connect lighting, indoor and outdoor.
4. Furnish, install, and connect power and signal lines to all instrumentation equipment, and accessories.
5. Furnish, install, and connect all electrical conduit, duct and cables.
6. Furnish, install, and connect all telephone boxes, outlets, etc.
7. Furnish, install, and connect all power distribution equipment.
8. Furnish and install standby power equipment.

1.03 SHOP DRAWINGS, DESCRIPTIVE LITERATURE, INSTALLATION, OPERATION AND MAINTENANCE INFORMATION

A. Shop Drawings including descriptive literature and/or installation, operation and maintenance instructions shall be submitted per Section 01300.

B. Shop Drawings shall be submitted on the following materials specified in this Division:

1. Conduit - all types and sizes, including liquid-tight flexible.
2. Boxes - all types and sizes.
3. Coal tar epoxy paint.
4. Wiring devices.
5. Device plates.
6. Metal framing system (Strut type channel).
7. Conduit fittings, expansion joints, support hardware.
8. Motor control equipment - including individually mounted items.
9. Power distribution equipment - including individually mounted items.
10. Adjustable speed equipment and accessories.
10. Miscellaneous spare parts and hardware.
12. Wire - all types and sizes.

13. Light fixtures - all types.

14. Wire markers, signs and labels.

15. Lightning/transient suppressors.

16. Motors.

17. Transformers.

18. Standby power equipment and accessories.

C. The Engineer reserves the right to make modifications to motor control and power distribution equipment ratings after Shop Drawing review, if the Shop Drawings are submitted prematurely (prematurely meaning submitted before all utilization equipment has been reviewed and accepted). Cost of modifications shall be the Contractor's responsibility.

1.04 SYMBOLS AND ABBREVIATIONS

A. The symbols and abbreviations general follow standard electrical and architectural practice, however, exceptions to this shall be as shown on the Contract Drawings.

1.05 COORDINATION WITH OTHER TRADES

A. The Contractor shall coordinate the electrical work with that of other trades to ensure proper final location of all electrical equipment and/or connections. The Contractor shall verify door swings to see that light switches are located properly.

1.06 CODES

A. The minimum standard for all work shall be the latest revision of the Kentucky Building Code (KBC), and the National Electrical Code (NEC). Whenever and wherever state and/or local laws or ordinances and/or regulations and/or the Engineer's design require a higher standard that the current NEC or KBC, then these laws and/or regulations and/or the design shall be followed.

B. Following is a list of other applicable Standards or Codes:

1.	Kentucky Building Code	KBC
2.	National Electrical Code	NEC
3.	National Electrical Safety Code	NESC
4.	Underwriters Laboratories, Inc.	UL
5.	Factory Mutual System	FM
6.	National Fire Protection Association	NFPA
7.	National Electrical Manufacturers Association	NEMA
8.	Occupational Safety and Health Administration	OSHA
9.	Insulated Cable Engineers Association, Inc.	ICEA

10. Illuminating Engineering Society of North America	IES
11. Instrument Society of America	ISA
12. Institute of Electrical and Electronic Engineers, Inc.	IEEE
13. Certified Ballast Manufacturers Association	CBM
14. American National Standards Institute, Inc.	ANSI
15. Anti-Friction Bearing Manufacturers Association, Inc.	AFBMA
16. Joint Industry Council	JIC
17. American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc.	ASHRAE
18. Federal Communications Commission	FCC
19. American Society for Testing and Materials	ASTM
20. American Wood Preservers Association	AWPA
21. Rural Electrification Association	REA

1.07 INSPECTIONS AND PERMITS

A. Inspection of the electrical system on all construction projects is required. If the local government has appointed a state licensed inspector, the Contractor shall be required to use that person to perform the inspections. If a locally mandated inspector does not exist, the Contractor shall select and hire a state licensed inspector, who has jurisdiction before any work is concealed. The Contractor shall notify the electrical inspector in writing, immediately upon notice to proceed, and a copy of the notice shall be submitted to the Engineer.

B. At the time of completion of the project, there shall be furnished to the Owner a certificate of compliance, from the agency having jurisdiction pursuant to all electrical work performed. The Engineer shall also receive a photostatic copy.

C. All costs incurred by the Contractor to execute the above mentioned requirements shall be paid by the Contractor at no extra cost to the Owner.

D. All permits necessary for the complete electrical system shall be obtained by the Contractor from the authorities governing such work. For further information, See Division 1.

1.08 STORAGE

A. All work, equipment, and materials shall be protected against dirt, water, or other injury during the period of construction.

B. Sensitive electrical equipment such as light fixtures, motor starters, controls, and panelboards, delivered to the job site, shall be protected against injury or corrosion due to atmospheric conditions or physical damage by other means. Protection is interpreted to mean that equipment shall be stored under roof, in a structure properly heated in cold weather and ventilated in hot weather. Provision shall be made to control the humidity in the storage area to 50 percent relative. The stored equipment shall be inspected periodically, and if it is found that the protection is inadequate, further protective measures shall be

employed. Electrical equipment other than boxes and conduit shall not be installed until the structure is under roof with doors and windows installed.

C. No light fixtures or device plates shall be hung or installed until after painting is completed; however, temporary lighting shall be provided by the Contractor.

D. The Contractor shall not store submersible pump units in the wetwell. If it is absolutely necessary to do so, the open power cable ends are to be suspended above the maximum flood elevation or maximum expected water level. If not stored in this manner, the Contractor may be called upon to replace the pump motors and cables with new units to ensure that water has not penetrated the cable and entered the motor housing.

1.09 MATERIALS

A. All materials used shall be new and at least meet the minimum standards as established by the NEC and/or National Electrical Manufacturers Association (NEMA). All materials shall be UL listed for the application, where a listing exists. Additional requirements are found in Division 1. All equipment shall meet applicable FCC requirements and restrictions.

B. The material and equipment described herein has been specified according to a particular trade name or make to set quality standards. However, each Contractor has the right to substitute other material and equipment in lieu of that specified, other than those specifically mentioned at matching or for standardization, providing such material and equipment meets all of the requirements of those specified and is accepted, in writing by the Engineer.

C. The reuse of salvaged electrical equipment and/or wiring will not be permitted unless specified herein or indicated on the Contract Drawings.

D. All salvaged or abandoned electrical materials shall become the property of the Contractor and shall be removed from the job site upon completion of the project, unless otherwise noted on the Contract Drawings or specified herein.

1.10 ERRORS, CORRECTIONS, AND/OR OMISSIONS

A. Should a piece of utilization equipment be supplied of a different size or horsepower than shown on the Contract Drawings, the Contractor shall be responsible for installing the proper size wiring, conduit, starters, circuit breakers, etc., for proper operation of that unit and the complete electrical system at no extra cost to the Owner.

B. It is the intent of these Specifications to provide for an electrical system installation complete in every respect, to operate in the manner and under conditions as shown in these Specifications and on the Contract Drawings. The Contractor shall notify the Engineer, in writing, of any omission or error at least 10 days prior to opening of bids. In the event of the Contractor's failure to give such notice, he/she may be required to correct work and/or furnish items omitted without additional cost. Further requirements on this subject may be found in the General Requirements, Division 1.

C. Necessary changes or revisions in electrical work to meet any code or power company requirement shall be made by the Contractor without additional charge.

1.11 GUARANTEES AND WARRANTIES

A. The Contractor shall guarantee all work including equipment, materials, and workmanship. This guarantee shall be against all defects of any of the above and shall run for a period of 1 year from the date of acceptance of the work, concurrent with the one year guarantee period designated for the general construction contract under which electrical work is performed.

Date of acceptance shall be considered to be the date on which all "punch list" items are completed ("punch list" is defined to be the written listing of work that is incomplete or deficient that must be finished or replaced/repaired before the Contractor receives final payment).

B. Repair and maintenance for the guarantee period is the responsibility of the Contractor and shall include all repairs and maintenance other than that which is considered as routine. (That is oiling, greasing, etc.) The Engineer shall be the judge of what shall be considered as routine maintenance.

C. Lamps shall bear the manufacturer's warranty.

1.12 TESTING

A. After the wiring system is complete, and at such time as the Engineer may direct, the Contractor shall conduct an operating test for acceptance. The equipment shall be demonstrated to operate in accordance with the requirements of these Specifications and the Contract Drawings. The test shall be performed in the presence of the Engineer or his authorized representative. The Contractor shall furnish all instruments and personnel required for the tests, as well as the necessary electrical power.

B. Before energizing the system, the Contractor shall check all connections and set all relays and instruments for proper operation. He shall obtain all necessary clearances, approvals, and instructions from the serving utility company and/or equipment manufacturers prior to placing power on the equipment.

C. Tests may be performed by the Engineer to determine integrity of insulation on wiring circuits selected by the Engineer at random.

D. Cost of utilities for testing done prior to beneficial occupancy by the Owner shall be borne by the Contractor.

1.13 CLEANUP

A. Cleanup shall be completed as soon as possible after the electrical installation is complete. All light fixtures, outlets, switches, starters, motor control centers, disconnect switches and other electrical equipment shall be free of shipping tags, stickers, etc. All painted equipment shall be left free of scratches or other blemishes, such as splattered or blistered paint, etc. All light fixture diffusers shall be clean and the interior of all motor controls, etc., shall be free of dust, dirt, wire strippings, etc. Surplus material, rubbish and equipment resulting from the work shall be removed from the job site by the Contractor upon completion of the work.

B. During construction, cover all Owner equipment and furnishings subject to mechanical damage or contamination in any way.

1.14 CUTTING AND PATCHING

A. Cutting and patching shall be held to an absolute minimum and such work shall be done only under the direction of the Engineer or Owner. The Contractor shall be responsible for and shall pay for all openings that may be required in the floors or walls, and he shall be responsible for putting said surfaces back in their original condition. Every attempt shall be made to avoid cutting reinforcing steel bars when an opening is required in a reinforced concrete wall or floor slab.

1.15 EXCAVATION AND BACKFILL

A. Excavation

1. Excavation for conduits shall be of sufficient width to allow for proper jointing and alignment of the type conduit used. Conduit shall be laid in straight lines between pull boxes and/or structures unless otherwise notes on the Contract Drawings. The cost of solid rock excavation shall be included in the lump sum bid with no extra pay allowed (unclassified).

B. Encasement/Backfill

1. All buried conduits shall be concrete encased. Backfill over the ductbank may contain rocks but must be mixed with sufficient earth to fill all voids.

1.16 SLEEVES, CHASES AND OPENINGS

A. Sleeves shall be required at all points where exposed conduits pass through new concrete walls, slabs, or masonry walls. Sleeves that must be installed below grade or where subject to high water conditions must be installed watertight.

B. Wiring chases shall be provided where shown on the Contract Drawings. The Contractor shall have the option of installing chases below surface mounted panelboards provided all structural requirements are met.

C. It is the Contractor's responsibility to leave openings to allow installation of the complete, operational electrical system. Openings required but not left shall be cut as outlined under cutting and patching. The Contractor shall coordinate all holes and other openings with necessary diameters for proper firestopping.

1.17 POWER COMPANY COORDINATION

A. The Contractor is responsible for coordinating all activities onsite by the power company.

B. All power company metering equipment shall be electrically located "upstream" of any manual/automatic transfer equipment on projects requiring onsite emergency power generation equipment.

C. Any special provisions required by the serving electrical utility shall be as outlined on the Contract Drawings or as advised by the utility at the time of construction, and work required by these special provisions shall be executed with no extra cost to the Owner.

1.18 TEMPORARY ELECTRICAL POWER

A. The Contractor shall be responsible for providing temporary electrical power as required during the course of construction and shall remove the temporary service equipment when no longer required. Temporary power is also addressed in Division 1.

1.19 OVERCURRENT PROTECTION

A. Circuit breakers or fused switches shall be the size and type as written herein and shown on the Contract Drawings. Any additional overcurrent protection required to maintain an equipment listing by an authority having jurisdiction shall be installed by the Contractor at no extra cost to the Owner.

B. The Contractor shall submit to the Engineer actual nameplate data from motors shipped to the site, stating motor identification as well as characteristics. Overload relay thermal unit selection tables shall accompany the motor data. The Engineer will select thermal unit sizes from this data for use by the Contractor in ordering proper thermal units.

1.20 TRAINING

A. All manufacturers supplying equipment for this division shall provide the Owner's operations staff with training in the operation and maintenance on the equipment being furnished. The training shall be conducted at the project site by a qualified representative of the manufacturer.

B. The cost of this training shall be included in the bid price.

C. The required training shall consist of both classroom and hands-on situation. Classroom training shall include instruction on how the equipment works, its relationship to all accessories and other related units, detailed review of shop drawings, detailed presentation of written O & M instructions, troubleshooting and record-keeping recommendations. Hands-on-training shall include a review of the manufacturer's O & M instructions, check out of each operator to identifying key elements of the equipment, tear down as appropriate, calibration, adjustment, greasing and oiling points, and operating manipulations of all electrical and mechanical controls.

D. The training shall be scheduled through the Contractor with the Owner. The timing of the training shall closely coincide with startup of the equipment, but no training shall be conducted until the equipment is operational.

E. The minimum number of hours to be provided by manufacturers supplying equipment on this project shall be in accordance with the following table:

	Training Hours	
Item	Classroom	Hands-on
Standby Power System & Accessories	2	2
Variable Speed Systems	2	2
Automatic Level/Pressure Control System	1	1

F. At least 60 days prior to the training the manufacturer shall submit through the Contractor to the Engineer an outline of the training proposed for the Engineer's review and concurrence.

G. The Owner reserves the right to videotape all training sessions.

1.21 MAINTAINING CONTINUOUS ELECTRICAL SYSTEM AND SERVICE

A. Existing service(s) continuity shall be maintained at all times. In no way shall the installation and/or alteration of the electrical work interfere with or stop the normal operation of the existing facilities, except where prior arrangements have been made

B. When additions and taps to existing service(s) require electrical outages of duration in excess of a few minutes, arrangements shall be made in advance for such outages. All outages shall be held to an acceptable minimum with none exceeding 8 hours continuous duration. If necessary, cuts shall be performed on premium time. If performed at night, requiring a general outage, the Contractor shall furnish an auxiliary source of light and power as required. Under no circumstances shall an electrical outage of any duration be initiated until the Owner and Engineer have concurred, and as far as possible in advance.

C. See Section 01520 for additional requirements.

1.22 GROUNDING AND BONDING

A. All metallic conduit, cabinets, equipment, and service shall be grounded in accordance with the latest issue of the National Electrical Code. All supporting framework and other metal or metal clad equipment or materials which are in contact with electrical conduit, cable and/or enclosures, shall be properly grounded to meet the code requirements.

1.23 RELATED SPECIFICATION DIVISIONS

A. The following divisions contain Specifications on utilization equipment, equipment accessories, and procedures related to execution of the electrical work, and are included here for the Contractor's information. Bids shall still be based on complete Contract Documents.

Division 0 - Bidding Requirements, Contract Forms, and Conditions of the Contract
Division 1 - General Requirements
Division 11 - Equipment
Division 15 – Mechanical
Division 17 - Instrumentation

1.24 SERVICE ENTRANCE

A. Conductors and terminations for service entrances shall be furnished and installed by the Contractor. Voltage, phase, and number of wires shall be as shown on the Drawings. Clearances for overhead entrance wires shall be per power company, NEC, and NESC requirements.

B. Any details not shown on the Drawings or written in the Specifications pertaining to the service entrance shall be per power company requirements. It is the Contractor's responsibility to contact the utility prior to bidding and obtain any special requirements or costs they will be imposing. Those costs shall be included in the bid.

C. On underground service entrances from pad mounted transformers, the Contractor shall be responsible for furnishing and installing all primary, secondary, and metering conduits, as well as secondary service/metering conductors. The Contractor shall be responsible for furnishing pull wires in primary conduits for use by the power company. The Contractor shall be responsible for fabricating the required concrete pad that the transformer will be mounted on. The Contractor shall also mount the meter base furnished by the power company.

1.25 CONTRACTOR LICENSING

A. The Contractor performing the electrical work on this project shall be locally licensed, if required by local law or ordinance. If the Contractor has passed the State test, it may not be necessary to meet local testing requirements. It shall be the Contractor's responsibility to investigate these requirements and comply with same.

1.26 ANCHORING/MOUNTING

A. Electrical conduits and/or equipment shall be rigidly supported. Anchors used shall be metallic expansion type, or if appropriate to prevent spalling concrete, epoxy set type. Plastic or explosive type anchors are prohibited.

B. All supports shall be consistent with the latest edition of the KBC and ASCE 7.

1.27 ELECTRICAL COMPONENT MOUNTING HEIGHTS

A. Unless otherwise indicated, mounting height for components shall be as defined herein. In cases of conflicts with architectural or structural aspects, the components may be relocated. If an indicated height conflicts with a code requirement, the code shall govern.

B. Mounting heights are given from finished floor elevation to the centerline of the component, unless otherwise noted.

	Component	Height	Comments
1.	Wall type light switch	4'-0"	To top of box
2.	Low wall outlet	16"	To bottom
3.	Medium height wall outlet	4'-0"	
4.	Medium height telephone outlet	4'-0"	
5.	High wall outlet or fixture	7'-0"	
6.	Wall type buzzers, horns, etc.	8'-0" Max.	Top 2" below ceiling
7.	Push-button or control stations	4'-0"	
8.	Top of panelboards or control panels	6'-6"	Maximum (except for handicapped areas)
9.	Top of telephone back boards	6'-6"	Maximum
10.	Top of switch handle on motor control center	6'-6"	Maximum
11.	Top of local motor controller	6'-0"	Maximum
12.	Top of local disconnect switch	6'-0"	Maximum
13.	Wall mount exterior light fixtures	8'-0"	or as shown
14.	Wall mount emergency light fixtures	6'-6"	Maximum to test button
15.	Wall thermostats	4'-0"	To top of thermostat

In situations where there appears to be a conflict with Americans with Disabilities Act (ADA) legislation, utilize the ADA requirements herein.

1.28 HAZARDOUS AREA CLASSIFICATIONS

The following table identifies the applicable hazardous areas for this project, and the classifications for each. All equipment used in these areas shall be UL listed for the application, and all wiring methods shall be in accordance with Chapter 5 of the National Electrical Code. All conduits to these spaces from non-hazardous areas shall be properly sealed.

Location	**Area Classification**	**Extent of Hazardous Area**
Wetwell	Class I, Division 1, Group D	Entire Wetwell
Valve Vault	Class I, Division 2, Group D	Entire Vault
Diversion Structure/ Screenings Area	Class I, Division 1, Group D	Entire Structure
Meter Vaults	Class I, Division 2, Group D	Entire Vault
Wet Weather Storage (covered)	Class I, Division 1, Group D	Entire Structure
Electrical Building	Unclassified	Entire Building

Note: These ratings are based on no continuous ventilation and some may be rerated if continuous ventilation is provided (per NFPA 820).

1.29 RECEIPTS

A. Some sections of the Specifications call for equipment, materials, accessories, etc. to be provided and "turned over to the Owner" or like requirements. The Contractor shall obtain a receipt for each item turned over, signed by the Owner or his representative. A copy of this receipt shall be transmitted to the Engineer.

B. When a question arises concerning whether items have been turned over to the Owner, and there is no signed receipt, it may be assumed that the items were not provided.

1.30 POWER SYSTEM STUDIES

A. General

1. The Contractor shall provide Short Circuit Studies, Protective Device Evaluation Studies, Protective Device Coordination Studies, and Arc Flash Studies performed by a professional registered electrical engineer currently registered in the State of Kentucky for the entire electrical system. The studies shall be performed in accordance with 399-1997, IEEE Recommended Practice for Industrial and Commercial System Power Analysis (IEEE Brown Book). The studies shall be submitted to the Engineer prior to receiving final approval of the distribution equipment shop drawings and/or prior to release of equipment for manufacture. If formal completion of the studies may cause delay in equipment manufacture, approval from the Engineer may be obtained for a preliminary submittal of sufficient study data to insure that the selection of device ratings and characteristics will be satisfactory.

2. The studies shall include all portions of the electrical distribution system from the utility company protective devices, the normal and standby power sources down to and including the 480 volt feeder protective devices for each feeder. The study shall include all low and medium voltage switchgear, MCCs, and panelboards. System connections and those which result in maximum fault conditions shall be adequately covered in the study.

3. In the event that the short circuit study requires a higher interrupting and/or withstand rating of equipment than that which is indicated in the Contract Documents, the Contractor shall furnish and install the equipment as required based on the study with no extra cost to the Owner.

4. In the event that the protective device coordination study indicates that different settings or equipment is required than that which is specified, the Contractor shall furnish and install the equipment based on the study with no extra cost to the Owner.

B. Data Collection for the Studies

1. The Contractor shall provide the required data for preparation of the studies. The preparer of the studies shall furnish the Contractor with a listing of the required data immediately after award of the Contract.

2. The Contractor shall expedite collection of the data to assure completion of the studies as required for final approval of the distribution equipment shop drawings and/or prior to release of the equipment for manufacture.

C. Short Circuit Study and Protective Device Evaluation Study

1. The short circuit study shall be performed with the aid of a digital computer program and shall be in accordance with the latest editions of IEEE Std. 399 and IEEE Std. 141.
2. The study input data shall include the utility company's short circuit contribution, resistance and reactance components of the branch impedances, the X/R ratios, base quantities selected, and other source impedances.

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3. Short circuit close and latch duty values and interrupting duty values shall be calculated on the basis of assumed three-phase bolted short circuits at each bus, switchgear, medium and low-voltage motor control center, distribution panelboard, pertinent branch circuit panel and other significant locations through the system. The short circuit tabulations shall include symmetrical fault currents, and X/R ratios. For each fault location, the total duty on the bus, as well as the individual contribution from each connected branch, shall be listed with its respective X/R ratio.

4. A protective device evaluation study shall be performed to determine the adequacy of circuit breakers, molded case switches, automatic transfer switches, and fuses by tabulating and comparing the short circuit ratings of these devices with the calculated fault currents. Appropriate multiplying factors based on system X/R ratios and protective device rating standards shall be applied. Any problem areas or inadequacies in the equipment due to short circuit currents shall be promptly brought to the attention of the Engineer.

5. All equipment furnished shall meet the requirements of this study, with no extra cost to the Owner.

D. Protective Device Coordination Study

1. A protective device coordination study shall be performed to provide the necessary calculations and logic decisions required to select or to check the selection of power fuse ratings, protective relay characteristics and settings, ratios and characteristics of associated current transformers, and low voltage circuit breaker trip characteristics and settings.

2. The coordination study shall include all low voltage classes of equipment from the utility company service protective devices down to and including the main circuit breakers of motor control centers. The phase and ground overcurrent protection shall be included as well as settings of all other adjustable protective devices.

3. The time-current characteristics of the specified protective devices shall be drawn on log-log paper. The plots shall include complete titles, representative one-line diagram and legends, significant motor starting characteristics, complete parameters of transformers, complete operating bands of low voltage circuit breaker trip curves and fuses. The coordination plots shall indicate the types of protective devices selected, proposed relay taps, time dial and instantaneous trip settings, transformer magnetizing inrush and ANSI transformer withstand parameters, cable thermal overcurrent withstand limits and significant symmetrical and asymmetrical fault currents. All restrictions of the National Electrical Code shall be adhered to and proper coordination intervals and separation of characteristic curves shall be maintained. The coordination plots for phase and ground protective devices shall be provided on a system basis. A sufficient number of separate curves shall be used to clearly indicate the coordination achieved.

4. The selection and settings of the protective devices shall be provided separately in a tabulated form listing circuit identification, IEEE device number, current transformer ratios and connections, manufacturer and type, range of adjustment and recommended settings. A tabulation of the recommended power fuse selection shall be provided for the medium voltage fuses where applied in the system. Any discrepancies, problem areas, or inadequacies shall be promptly brought to the attention of the Engineer.

E. Arc Flash Hazard Analysis

1. An Arc Flash Hazard Analysis shall be performed with the aid of a digital computer program in accordance with IEEE Std. 1584, "IEEE Guide For Performing Arc Flash Hazard Calculations", NFPA 70E, and OSHA 29-CFR, Part 1910 Subpart S.

2. Arc Flash Warning Labels and Bus Detail Sheets shall be produced for each bus. Labels shall be printed in color on adhesive backed labels. Labels shall be attached to the doors of the equipment. Each label and detail sheet shall list the following:

   a. Bus name

   b. System operating voltage

   c. Date of issue

   d. Flash hazard protection boundary

   e. Limited approach boundary

   f. Restricted boundary

   g. Prohibited boundary

   h. Incident energy level

   i. Required personal protective equipment class

      In addition, each Bus Detail Sheet shall list the following:

      1). Upstream Protective Devices Names, Type and Settings

3. Arc Flash Evaluation Summary Sheets shall be produced. Summary sheets shall list the following:

   a. Bus name

   b. Upstream protective device name, type and settings

   c. Bus line-to-line voltage

   d. Bus bolted fault

   e. Protective device bolted fault current

   f. Arcing fault current

   g. Protective device trip / delay time

   h. Breaker opening time

   i. Solidly grounded column

   j. Equipment type

   k. Gap

   l. Arc flash boundary

   m. Working distance

   n. Incident energy

   o. Required personal protective equipment class

4. Analyze the short circuit, protective device coordination, and arc flash calculations and highlight any equipment that is determined to be underrated or causes an abnormally high incident energy calculation. Propose approaches to reduce the energy levels. Proposed major corrective modifications will be taken under advisement by the Engineer and the Contractor will be given further instructions.

F. Study Report

1. The results of the power system studies shall be summarized in a report. The report shall be submitted to the Engineer. The report shall be submitted for review and acceptance prior to submittals for medium voltage switchgear, medium voltage motor control equipment, low voltage switchgear and switchboards, motor control centers, variable frequency drives, panelboards, and similar electrical equipment.

2. The report shall include the following sections:

   a. Description, purpose, basis and scope of the study and a detailed single line diagram with "nodes" cross-referenced to the calculated values tabulated in the study report of that portion of the power system which is included within the scope of the study.

   b. Tabulations of circuit breaker, fuse and other protective device ratings versus calculated short circuit duties and commentary regarding same.

   c. Protective device time versus current coordination curves, tabulations of relay and circuit breaker trip settings, fuse selection, and commentary regarding same.

   d. Fault current calculations including a definition of terms and guide for interpretation of computer printout.

3. Prior to commencing the work, the preparer the studies shall meet with the testing firm that will do the relay field testing and the Owner's representative at the site for a walk through of the facility to insure that existing conditions are taken into account.

4. The study shall include a detailed explanation of all software programs and procedures used to arrive at the calculated values, settings, and drawings (e.g. single line diagrams) showing fault valves at all busses.

PART 2 - PRODUCTS

Not Applicable.

PART 3 - EXECUTION

Not Applicable.

END OF SECTION

SECTION 16060 - SECONDARY GROUNDING

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. Grounding shall be done in accordance with the NEC, as described in these Specifications, and as shown on the Contract Documents.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Grounding equipment shall be Cadweld, T&B Blackburn, ITT Weaver, Copperweld Bimetallics Group, or equal.

PART 3 - EXECUTION

3.01 INSTALLATION/APPLICATION/ERECTION

A. Grounding shall utilize a supplemental driven ground rod system in a bed to achieve the design ground resistance.

B. The ground system shall be continuous with all structures on a common ground. This can be accomplished by bonding all conduits together and bonding to the ground bus at each motor control center. Bonding jumpers shall be required at all pull boxes, and at all motor casings. A separate grounding conductor shall be pulled in all conduits in addition to wire counts shown on Drawings.

C. Ground rods shall be 3/4" x 10'-0" copper clad type. Where multiple rods are driven, they shall be separated by at least 10 feet to assure maximum effect.

D. Ground resistance between ground and absolute earth shall not exceed 5 ohms.

E. All grounding and grounding electrode systems shall be as required by the NEC as for types of electrodes utilized and sizing of grounding conductor to service equipment from the electrode system. These shall include footer rebar, buried metal water pipe, buried bare copper conductor, etc.

F. All grounding electrode system connections shall be made using exothermic welds, Cadweld, or equal. No splices are allowed in the grounding electrode conductor.

G. An insulated, isolated ground shall be run from the service entrance to panels serving computers.

H. Should ground rods be impractical for use due to rocky conditions, then grounding electrode plates may be used after acceptance by the Engineer on a case by case basis.

3.02 FIELD QUALITY CONTROL

A. Testing

1. The Contractor shall be required to provide all labor, tools, instruments, and materials as necessary to perform testing of the grounding electrode system. Results shall be submitted in writing to the Engineer. The testing shall be done to determine the effectiveness of the selected grounding scheme and to see that it conforms with resistance specified (5 ohms maximum).

2. The testing should be done using a fall-of-potential method test at the point of grounding electrode conductor connection to main power distribution equipment and at each separately derived system or MCC. The test shall be performed no sooner than 48 hours after a rainfall event.

3. The written report should contain the following information:

   a. Type of ground scheme used, i.e., building steel, driven rod, mat, etc.

   b. Type of instrument used.

      1) Manufacturer

      2) Model Number

      3) Confirm fall-of-potential test

      4)* Serial Number

      5)* Where instrument was obtained

      * These 2 items are required so that the same instrument may be utilized should reproduction of the test be necessary due to unsatisfactory readings/instrument miscalibration.

   c. Ground resistance readings obtained at various test distances.

   d. Ground resistance/distance curve.

   e. Value of Grounding Electrode Resistance at knee of curve.

   f. Sketch showing setup of instrumentation and location of grounding electrode and test probes.

   g. Proposed method to achieve the specified resistance, should an unacceptable reading be obtained.

   h. Ground resistance readings obtained (if applicable) after modifications incorporated.

END OF SECTION

SECTION 16070 - SUPPORTING DEVICES

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. All electric equipment shall be rigidly mounted, and installed using supporting devices as indicated on the Contract Drawings, as required by the work, and described herein.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. "Kindorf," "Unistrut," or equal.

2.02 MATERIALS

A. All mounting brackets and strut shall be aluminum. Fasteners used to mount equipment shall be stainless steel.

B. Aluminum support members shall not be installed in direct contact with concrete. Stainless steel or non-metallic "spacers" shall be used to prevent contact of aluminum with concrete.

PART 3 - EXECUTION

3.01 ANCHORING CABINETRY

A. All free standing equipment shall be anchored to its foundation using expansion bolts of the size and number recommended by the equipment manufacturer.

3.02 SEISMIC CONSIDERATIONS

A. Where indicated, seismic restraints shall be provided for electrical equipment.

END OF SECTION

SECTION 16075 - ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.01 EQUIPMENT LABELING

A. All starters, feeder units in panelboards, switchboards, disconnects, instruments, etc. shall be marked to indicate the motor, outlet, circuit they control, or variable monitored. Marking is to be done with engraved laminated nameplates and shall bear the designation shown on the Contract Drawings where this information is given. Nameplates shall be fastened to equipment with stainless steel screws, minimum of one each side. In no way shall the installation of mounting screws void the NEMA enclosure rating of the equipment in which they are installed. If there are more than one identical unit, they shall be given consecutive numbers or other descriptions as designated by the Engineer. Nameplate background color shall be white, with black engraved letters, unless otherwise noted.

B. Branch circuits in lighting panels shall be typed on a card suitable for the card frame furnished with the panel. The card shall bear the panel designation listed on the Contract Drawings where this information is given, as well as indicate what each circuit controls.

C. Motor control centers, individual wall mounted starters, panelboards, and disconnect switch shall be labeled with vinyl self-adhesive signs that warn of "High Voltage" (state the specific voltage). Main service entrance conduits to a building, where exposed, shall be labeled with the voltage of the service they carry. Other major equipment such as transformers, transfer switches, generator sets, pump control panels, etc., shall be labeled as such. The type of labels to be used shall have orange as the basic color to conform with OSHA requirements, letters shall be black. The labels shall be of proper size to fit flatly on the surface of the enclosure to make for a neat appearance and not interfere with the operating function of the device it is attached to. These labels shall be as manufactured by the Brady Identification Systems Division, Safety Sign Company, or equal.

D. Furnish and install "Authorized Personnel Only" signs by doors into all power distribution equipment rooms/buildings. Furnish and install other signs as indicated on the Contract Drawings.

PART 2 - PRODUCTS

Not applicable

PART 3 - EXECUTION

Not applicable

END OF SECTION

SECTION 16100 - ELECTRICAL DEMOLITION

PART 1 – GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, equipment, materials, and supplies necessary for and reasonably incidental to demolition of work hereinafter specified, indicated on drawings, required or intended for completion of the work.

B. Major items included under demolition work include, but are not limited to:

1. Exterior low voltage wiring and conduits.

2. Exterior medium voltage conduit, wire, transformers and poles.

C. Repair those areas damaged under demolition work once new services and systems have been installed.

1.02 SUBMITTALS

A. No submittals are anticipated under this Section.

1.03 JOB CONDITIONS

A. Provide adequate protection to persons and property. Execute work in such a manner as to avoid interference with required operations and use of or passage to and from adjoining buildings and facilities.

B. Demolition work of equipment necessary for the operation of the power and communication systems to be coordinated with the installation of new equipment. The demolition and installation work is to be done as quickly as possible to minimize any burdens on the Owner.

1.04 CONDITION OF EXISTING FACILITIES

A. Contractor shall verify the areas, conditions and features necessary to tie new work into existing construction. This verification shall be done prior to submittal of shop drawings, fabrication or erection, construction or installation. The Contractor shall be responsible for the accurate tie-in of the new work to existing facilities.

PART 2 – PRODUCTS

NOT APPLICABLE

PART 3 – EXECUTION

3.01 SCHEDULES

A. Schedule all demolition work as to cause minimal interference with existing facility operations. Refer to Specification Divisions 0 and Division 1 for additional requirements.

B. Obtain prior approval of the Owner at least seven days in advance before starting demolition of any equipment. Under no circumstances will demolition work be approved until new equipment is ready for installation.

3.02 PREPARATION

A. Disconnect or arrange for disconnection of utility service connections to equipment and areas to be demolished before starting demolition.

B. Preserve in operating condition all active utilities transversing the project site. Protect all equipment that remains (electrical and mechanical) during demolition, and repair all damage caused by this work to satisfaction of Engineer.

3.03 APPLICATION

A. Maintain the continuity of the existing branch circuits serving all existing light fixtures that are to remain, whether indicated or not on the drawings.

B. All existing walls, ceilings, floor slabs, etc., being cut or damaged under this Contract shall be patched back to match existing by General Contractor.

C. All existing switchgear, lighting fixtures, receptacles, control equipment and switches being removed shall be disposed of by the Contractor. Refer to 16050 for more details.

D. Remove exposed ground conductor back to source or point of contact with slab. Cut conductor off below slab and abandon with hole being patched back to match existing surface (floor, wall or ceiling). If reusable, simply disconnect ground conductor.

E. Conduits, wire and wood products that are not salvageable shall be disposed of legally.

F. Primary work shall be completed with all facilities kept in service or with short periods of scheduled momentary outages.

G. Holes in slabs or into classified areas to be patched to provide a gas, vapor and watertight barrier.

3.04 STORAGE AND HANDLING

A. The Owner reserves the right to save materials that are a part of the demolition work, and the Contractor shall turn over and store any such materials at the Owner's direction.

B. All materials not turned over to Owner shall become property of Contractor and removed promptly from project site at no additional cost to the Owner. Any permits or fees for disposal shall be the responsibility of the Contractor.

3.05 CLEANUP

A. Burn no materials or debris on premises.

B. Remove from site rubbish and debris found thereon and, except as otherwise specified, materials and debris resulting from work of demolition. Leave site in safe and clean condition.

END OF SECTION

SECTION 16120 - CONDUCTORS AND CABLES

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. All wire and cable shall conform to the latest requirements of the NEC and shall meet all ASTM/UL specifications. Wire and cable shall be new; shall have size, grade of insulation, voltage rating and manufacturer's name permanently marked on the outer covering at regular intervals. Complete descriptive literature shall be submitted to the Engineer for review and acceptance prior to installation.

B. Building wire #12 - #1 shall be applied based on a 60 degree Celsius temperature rise. Building wire larger than #1 may be applied at its 75 degree Celsius temperature rise.

1.02 DELIVERY, STORAGE AND HANDLING

A. Wire and cable shall be suitably protected from weather and damage during storage and handling and shall be in first class condition when installed.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Building Wire (types "THWN" and "THW"-cu.) – "Southwire," "Collyer," "American," "Carol," or equal.

B. Control Cables (Shielded or unshielded) 600V max. – "Belden," "Eaton-Dekoron," "Okonite," or equal.

C. Instrumentation Cables (Shielded) 600V mx. – "Eaton-Dekoron," "Manhatton," "American," "Belden," "Okonite," or equal.

D. VFD cable for motor branch circuits from VFD's: "Belden", "Draka", "Service Wire Co", or equal.

2.02 MATERIALS

A. General

1. In general, all conductors shall be 98 percent conductive, annealed copper unless otherwise noted on the Contract Drawings.

2. Conductors shall be type THW or THWN insulation. Conductor size shall be AWG (American Wire Gauge) Standard. Minimum conductor size shall be AWG number 12 except branch circuits in excess of 75 feet from panel to first outlet not smaller than no. 10 AWG. Minimum voltage rating shall be 600 volts. conductors for small power may be solid (i.e. lighting, receptacles), but conductors for control work shall be stranded.

3. Conductors with high temperature rated insulations and special construction shall be used where required in connecting to light fixtures or appliances that have special requirements.

B. VFD Cable

1. The cable shall be 600V/1000V rated, with stranded tinned copper conductors, shielded, suitable for use with Variable Frequency Drives.

2. The insulation shall be rated for 90 degrees Celsius Wet/Dry operating temperature.

3. Accessories (terminations) shall have ratings that are at least equal to those of the cable.

4. All cables shall be round.

5. Cable shall be suitable for use in wet/dry locations, indoors and outdoors, in cable trays, in conduits, trenches, and in underground ducts and direct burial.

6. The conductor shall be annealed stranded tinned copper per ASTM B3, B8, and B33.

7. The insulation thickness shall have a minimum average wall thickness of 30 mils. The insulation material must be XLPE with an XHHW-2 listing per UL 44. Each insulated conductor shall be identified in accordance with ICEA Method 4 color coding.

8. The insulated conductors are to be cabled together with a minimum of one ground wire. The ground wire(s) are to have a minimum circular mil area equivalent to one circuit conductor. Fillers shall be included as necessary to make the cable round.

9. The cabled assembly shall be shielded using one of two methods:

   a. Applying helically two 2-mil copper tapes. The shield shall provide 100% coverage over the assembly.

   b. Applying an 80% minimum coverage tinned copper braid shield used in conjunction with an Aluminum Foil shield tape.

10. All cables shall have a continuous overall outer sheath of Polyvinyl Chloride (PVC), suitable for 90 degree Celsius use.

11. The jacket shall be resistant to abrasion, rated for direct burial, sunlight resistant, and flame resistant in accordance with UL 1277.

12. The following permanent legend shall be clearly embossed or printed at approximately 2 foot intervals on the outer jacket for the entire length of the cable:

    a. Manufacturer's name and or Trade Mark.

    b. Number of conductors and size (-- AWG).

    c. Type of insulation (XLPE) or NEC Listed Conductor Type (XHHW-2).

    d. Voltage rating.

    e. TC-ER rating.

    f. 1000V Flexible Motor Supply Cable rating.

    g. Sequential footing marking at 2 foot intervals.

13. Only one continuous (without splices) length of cable shall be shipped on a reel. Both ends shall be waterproof sealed, secured, protected from damage, and both ends shall be available for testing.

PART 3 - EXECUTION

3.01 INSTALLATION/APPLICATION/ERECTION

A. General

1. Conductors shall be continuous from outlet to outlet and no splices shall be made except accessible in junction or outlet boxes. Wire connectors of insulating material or solderless pressure connectors, properly taped, shall be used for all splices in wiring, wherever possible.

2. Conductors shall be color coded in accordance with the following schedule:

	480/277V 3 Phase	208/240V 3 Phase	120/240, Single Phase
Phase A	Brown	Black	Black
Phase B	Orange	Red	Red
Phase C	Yellow	Blue	
Neutral (Grounded)	White or Light Gray	White or Light Gray	White or Light Gray
3-Way Tracers			Blue
Grounding	Green	Green	Green
Remote Energized Conductors (Control)			Yellow
Control	Std. Code	Std. Code	

3. Conductors shall be pulled into raceways in strict accordance with manufacturer's recommendations.

4. Ample slack conductors shall be allowed at each terminal point, and pull or junction box, to permit installation with ease and without crowding.

5. All conductors terminating at terminal blocks shall be identified with numbers and/or letters identical to circuit or control identification.

6. No conductors shall be drawn into conduits until all work which may cause wire or cable damage is completed. Wire pulling shall be accomplished utilizing machinery and accessories intended for the purpose.

7. All connections and splices shall be made in accordance with conductor manufacturer's recommendations, and as written herein.

8. In general, feeder sizes shown are based on no more than three current carrying conductors in a conduit. Multiple small branch circuit feeders may be combined in a common conduit, provided conductors are derated in accordance with NEC article 310-15.

9. Unless otherwise specifically indicated, neutrals may not be shared.

B. Feeders

1. All feeders are of the secondary type, below 600 volts, unless otherwise noted. Secondary feeder voltage shall be 480 volt, as noted in the Contract Drawings. Three phase, 4 wire for power and 208/120 volt, 3 phase, 4 wire for general lighting, unless otherwise noted. The Contractor shall furnish and install all feeders from the distribution center(s) to each of the other structures/subpanels as shown on the Contract Drawings.

2. Wire shall be factory color coded for each phase and neutral, with green used for the ground conductor. As far as practical, all feeders shall be continuous from origin to panel termination without running splices in intermediate pull boxes.

C. Control Cable

1. Control cable shall be the size and have the number of conductors shown on the control system drawings. Control cable shall be used for motor controls and monitoring only. Color coding shall be ICEA, Method 1. Control cables between buildings shall be underground in conduit of the size shown in the control system schematic. Cabling shall provide a minimum of 25 percent spare conductors. Voltage rating shall be 600 volts.

D. Instrument Cable

1. General

a. All signal lines should be constructed of individually twisted pairs (6 to 10 twists per foot), including thermocouple extension leads. Cables should be made of twisted pairs, with all lays and pairs twisted in the same direction for maximum flexibility.

b. Wire size is #16 AWG minimum.

c. Stranded tinned copper conductor shall be used for all wiring other than thermocouple extension leads.

d. Insulation resistance at 68 degrees Fahrenheit between conductors and between conductors and ground should be at least 500 megohms per 1,000 feet.

e. Multi-pair cable should be jacketed with poly-vinyl-chloride, polyethylene or Teflon at least 0.045" thick. Voltage rating shall be 600 volts.

2. Signal Wiring

a. Low level analog (less than 500 millivolt d-c). Use twisted pairs which may be cabled with other pairs carrying similar voltage levels. Foil wraps or equivalent shielding is required for each cable with the shield insulated from ground.

b. High level analog (greater than 500 millivolts d-c). Use twisted pairs which may be cabled with other pairs carrying similar voltage levels and current levels less than 100 ma. Shielding is required.

c. Analog outputs (normally 0-4 d-c or 4-20 ma). Same as b.

d. Contact inputs - use twisted pairs and run in separate conduit.

e. Contact outputs - same as d.

f. Pulse inputs - same as d.

3. Signal and Shield Grounding

   a. All shields must be grounded at one point only as close as possible to the signal source.

   b. Thermocouples may be grounded or ungrounded.

   c. Analog signals, if grounded, should be grounded as near the signal source as possible.

   d. Resistance bulbs should not be grounded.

4. Signal and Wiring Separation

   a. Analog signals shall be run in a separate conduit from contact or pulse signals.

   b. A minimum separation of 12 inches between analog signal leads and a-c power leads should be maintained. For a-c power leads carrying 100 amps or greater, a 24 inch separation should be maintained. Parallel runs should be limited to less than 500 feet. Perpendicular runs may be as close as 6 inches.

E. Submersible pump Power Cable

1. Power cables for submersible pumps shall be of the extra hard usage type suitable for submerged duty and able to withstand common corrosive agents found in water and wastewater. They shall be provided with high grade non-magnetic stainless steel relief cable grips installed at the pump end and high grade non-magnetic stainless steel support cable grips anchored to the wet well structure where they enter the wet well. The strain relief and support cable grips shall be as manufactured by Kellems, Slater/Flexcor, or equal. Non-metallic corrosion resistant grips may be used in lieu of stainless steel if available for the cable size.

F. Ethernet Cables

1. Ethernet cables shall be Category 6 rated.

2. Ethernet cables inside VFD cabinets shall be Category 6 rated and shielded.

3.02 FIELD QUALITY CONTROL

A. Testing

1. All testing shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

   a. Witness Shop Tests

      1) Not required.

   b. Shop Test

      1) Cable and wiring shall be tested in accordance with the applicable ICEA Standards. Wire and cable shall be physically and electrically tested in accordance with the manufacturer's standards.

   c. Field Tests

1) Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 1.

2) After installation, all wires and cables shall be tested for continuity. Testing for continuity shall be "test light" or "buzzer" style.

3) After installation, all wires and cables shall be tested for insulation levels. Insulation resistance between conductors of the same circuit and between conductor and ground shall be tested. Testing for insulation levels shall be as follows:

   - For 600V power and control cable, apply 1,000 VDC from a Megohmeter for one (1) minute for all 600V wires and cables installed in lighting, control, power, indication, alarm and motor feeder circuits. Resistance shall be no less than 100 Megohms.

   - 600V instrumentation signal cable shall be tested from conductor to conductor, conductor to shield, and conductor to ground using a Simpson No. 260 volt-ohmmeter, or approved equal. The resistance value shall be 200 Megohms or greater.

2. Low voltage wires and cables shall be tested before being connected to motors, devices or terminal blocks.

3. Voltage tests shall be made successively between each conductor of a circuit and all other conductors of the circuit grounded.

4. If tests reveal defects or deficiencies, the Contractor shall make the necessary repairs or shall replace the cable as directed by the Engineer, without additional cost to the Owner.

5. All tests shall be made by and at the expense of the Contractor who shall supply all testing equipment. Test reports shall be submitted to the Engineer.

END OF SECTION

092112BR

SECTION 16130 - RACEWAYS

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. This section of the Technical Specifications includes all raceways for accommodation of electrical conductors, communications conductors, sleeves for underground electrical installations, conduit stubs for future installations, fittings therefore and accessories.

B. All raceways shall be marked with the manufacturer's name or trademark as well as type of raceway and size. This marking shall appear at least once every 10 feet and shall be of sufficient durability to withstand the environment involved. All raceways shall be furnished and installed as outlined under Part 3 of this Specification.

C. All raceways and fittings shall be painted to match existing or surrounding surfaces except in mechanical spaces.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Tubular Raceways

1. Steel, Galvanized, Rigid, Heavy-Wall, Threaded – "Wheatland Tube Co.," "Triangle," "Allied Tube & Conduit Corp.," or equal.

2. Plastic (PVC); Type A (Thin Wall); Type 40 (or Schedule 40); Type 80 (or Schedule 80) (Heavy -Wall) – "Carlon," "Cantex," or equal.

3. Flexible Metal Conduit – "AFC," "Southwire," or equal.

4. Liquidtight Flexible Metal Conduit – "Carol Cable Co., Inc.," "Superflex," "OZ Gedney," or equal.

5. Liquid-Tight Flexible Non-Metallic Conduit - Type "LNM-P" as manufactured by Electri-Flex, Type "Ultralite" as manufactured by Southwire, Type "CNP" as manufactured by Anaconda, or equal.

6. Aluminum Conduit - "Wheatland Tube Co.", "Allied Tube & Conduit Corp.", or equal.

7. PVC Coated Metallic Conduit (PCMC) - "Plasti-Bond Red" as manufactured by Robroy Industries, "OCAL-Blue" as manufactured by Ocal, Inc., Perma-Cote Supreme by Perma-Cote Industries, or equal.

B. Raceway Fittings

1. Conduit fittings – "Crouse-Hinds," "Appleton," "OZ Gedney," or equal.

2. Non-metallic conduit fittings –"Carlon," "Cantex," or equal.

3. Flexible conduit fittings – "Raco," "T & B," "OZ Gedney," or equal.

4. PVC Coated Metallic Conduit fittings - "Plasti-Bond Red" as manufactured by Robroy Industries, "OCAL-Blue" as manufactured by Ocal, Inc., Perma-Cote Supreme by Perma-Cote Industries, or equal.

2.02 MATERIALS

A. Rigid Steel Conduit

1. Rigid steel conduit and fittings shall be of mild steel piping, galvanized inside and out, and shall conform to UL standards. The conduit and fittings hall be listed and labeled by UL as well. The galvanized coating of zinc shall be of uniform thickness applied by the hot-dipped process, and shall be applied also to the threads. It shall be further dipped in a chromic acid bath so as to chemically form a corrosion resistant protective coating of zinc chromate which has a characteristic yellow-green color. Each piece of conduit shall be straight, free from blisters and other defects, cut square, and taper reamed. It shall be delivered with plastic protectors on the threads.

B. Polyvinylchloride (PVC) Conduit

1. PVC conduit and fittings shall be Schedule 40, 80 heavy wall, or thinwall, as indicated in these Specifications manufactured to conform to UL standards. It shall be listed and labeled by UL. It shall have at least the same temperature rating as the conductor insulation. Expansion joints shall be used as recommended by the manufacturer in published literature. PVC systems shall be 90 degrees Celsius minimum UL rated, have a tensile strength of 7,000 psi @ 73.4 degrees Fahrenheit, flexural strength of 11,000 psi and compressive strength of 8,000 psi.

C. Flexible Conduit

1. Flexible metallic conduit shall be constructed from flexibly or spirally wound elecro-galvanized steel. Connections shall be by means of galvanized malleable iron squeeze type fittings, or tomic twist-in type in sizes not exceeding 3/4 inch. Liquidtight conduit shall be light gray in color and have sealtight fittings, type UA.

2. In hazardous locations where flexible connections are required, flexible couplings UL listed for the application shall be used. The couplings shall consist of stainless steel tubing and outer braid, with insulating liner. Female end fittings shall also be stainless steel, with removable steel close nipples. Couplings shall be O-Z/Gedney, or equal.

D. Liquid-Tight Flexible Metal Conduit

1. Liquid-tight flexible conduit (LFMC) shall be galvanized steel, single strip, with a copper strip interwoven and suitable as a grounding means. LFMC shall be UL listed. LFMC shall have an extruded moisture and oil-proof PVC jacket.

2. PVC coated or stainless steel watertight connectors shall be used with liquid-tight flexible metal conduit on both ends.

E. Liquid-Tight Flexible Non-Metallic Conduit

1. Liquid-tight flexible non-metallic conduit (LFNC) shall be constructed of PVC. LFNC shall be UL listed. LFNC shall have an extruded moisture and oil-proof PVC jacket.

2. Watertight connectors shall be used with liquid-tight flexible non-metallic conduit on both ends. LFNC shall be used to connect all vibrating equipment installed in sodium hypochlorite storage and transfer areas as specified herein, and other applications as directed by the Engineer or as indicated on the drawings.

F. Aluminum Conduit

1. Aluminum conduit shall be extruded from alloy 6063 and shall be the rigid type, non-toxic, corrosion resistant, and non-staining. It shall be manufactured per UL standards as well as listed/labeled by same.

2. Fittings, boxes, and accessories used in conjunction with aluminum conduit shall be die cast, copper free type. They shall be resistant to both chemical and galvanic corrosion. All covers shall have neoprene gaskets.

3. All aluminum conduit used for this project shall be UL listed for the purpose.

G. PVC Coated Metallic Conduit

1. PVC coated rigid steel conduit shall be rigid galvanized steel conduit covered with a bonded 40 mil (minimum) thickness PVC jacket and coated inside with urethane. The conduit shall comply with NEMA RN-1.

H. Conduit Fittings

1. Rigid Steel Conduit Fittings

a. Standard threaded couplings, locknuts, bushings, and elbows made only of steel or malleable iron are acceptable. Integral retractable type IMC couplings are acceptable also.

b. Locknuts: Bonding type with sharp edges for digging into the metal wall of an enclosure.

c. Bushings: Metallic insulating type, consisting of an insulating insert molded or locked into the metallic body of the fitting. Bushings made entirely of metal or nonmetallic material are not permitted.

d. Erickson (union-type) and set screw type couplings: Approved for use in concrete are permitted or use to complete a conduit run where conduit is installed in concrete. Use set screws of case hardened steel with hex head and cup point to firmly seat in conduit wall for positive ground. Tightening of set screws with pliers is prohibited.

e. Sealing fittings: Threaded cast iron type. Use continuous drain type sealing fittings to prevent passage of water vapor. In concealed work, installed fittings in flush steel boxes with blank coverplates having the same finishes as that of other electrical plates in the room.

f. Fittings for PVC coated rigid conduit shall be manufactured by the maker of the conduit.

2. Rigid Aluminum Conduit Fittings

a. Standard threaded couplings, locknuts, bushings, and elbows: Malleable iron, steel or aluminum alloy materials. Zinc or cadmium plate iron or steel fittings. Aluminum fittings containing more than 0.4 percent copper are prohibited.

b. Locknuts and bushings: As specified for rigid steel and IMC conduit.

c. Set screw fittings: Not permitted for use with aluminum conduit.

3. Expansion and Deflection Couplings

a. Accommodate 1.9 cm (0.75 inch) deflection, expansion, or contraction in any direction, and allow 30 degree angular deflections.

b. Include internal flexible metal braid sized to guarantee conduit ground continuity and fault currents in accordance with UL, and the NEC code tables for ground conductors.

c. Watertight, seismically qualified, corrosion-resistant, threaded for and compatible with rigid or intermediate metal conduit.

d. Jacket: Flexible, corrosion-resistant, watertight, moisture and heat resistant molded rubber material and stainless steel jacket clamps.

PART 3 - EXECUTION

3.01 PREPARATION

A. Exterior underground metallic conduits shall be degreased, pretreated, and coated with 2 coats of Carboline 888 epoxy, or equal. Other finishes may be acceptable upon the Engineer's review.

3.02 INSTALLATION

A. Conduit

1. All conduit shall be installed in a first class workmanship manner. It shall be installed in horizontal and vertical runs in such a manner as to ensure against trouble from the collection of trapped condensation and shall be arranged so as to be devoid of traps wherever possible. Special care shall be used in assuring that exposed conduit runs are parallel or perpendicular to walls, structural members, or intersections of vertical planes and ceilings. No open wiring is allowed.

2. Fittings or symmetrical bends shall be required wherever right angle turns are made in exposed work. Bends and offsets shall be avoided wherever possible, but where necessary, they shall be made with an approved conduit bending machine. All conduit joints shall be cut square, reamed smooth and drawn up tight, using couplings intended for the purpose.

3. Conduits shall be securely fastened to all sheet metal outlets, junction and pull boxes with double galvanized locknuts and insulating-grounding bushings as required by the NEC. Conduit crossings in insulating roof fill will require both conduits to be secured to the roof deck, and these crossings can only be made where the insulating fill is a minimum of 3 inches deep. Runs of exposed conduit shall be supported in accordance with the NEC using cast aluminum or malleable iron one hole pipe straps with spacers to provide an air space behind the conduit. Stainless steel minerallaac, one piece conduit clamps shall be acceptable where located such that building occupants are not in danger of inadvertent contact, since this type fitting has several sharp edges. In general terms, they may be considered in areas such as on or above ceilings, or high on walls. All conduit in walls and slabs shall be securely braced, capped (wooden plugs are prohibited), and fastened to the forms to prevent dislodgement during vibration and pouring of concrete.

4. During construction, all conduit work shall be protected to prevent lodgement of dirt, plaster or trash in conduits, fittings or boxes. Conduits which have been plugged shall be entirely freed of accumulations or be replaced. All conduits in floors or below grade shall

be swabbed free of debris and moisture before wires are pulled. Crushed or deformed conduit shall not be permitted.

5. Where GRS conduit penetrates a floor slab the conduit shall be painted with 2 coats of Koppers Bitumastic 300-M or equal to a point 6 inches above the penetration.

6. The final section of conduit connecting each motor or piece of utilization equipment subject to vibration shall be of the flexible type. Type "UA" shall be used in all process areas and in outdoor or wet locations. Flexible conduit to space heaters shall be long enough to allow swivel action.

7. All underground conduits entering a building shall be sealed against water/condensate entering around the conductors. Sealant may be silicone rubber based caulk.

8. In certain situations, conduit expansion joints shall be required to ensure against conduit and/or cable damage due to settling or thermal expansion and contraction. These expansion joints shall be required where required by the manufacturer or the Contract Drawings and shall be installed per manufacturers instructions.

9. Aluminum conduits shall not be in contact with concrete surfaces. Where aluminum conduits are routed along concrete surfaces, they shall be installed with one hole cast straps with clamp-backs to space the conduit ¼" away from concrete surface. Where aluminum conduit passes through concrete, CMU or brick walls, the penetration shall be made such that the aluminum conduit does not come in contact with concrete, CMU, brick or mortar. All penetrations shall meet or exceed the UL design standards. Aluminum conduit shall transition to PVC coated steel conduit where entering a concrete encasement, floor or ductbank.

10. Unless specifically identified on the Drawings as "Direct Buried," all conduits in the earth, including conduits below slabs-on-grade, shall be concrete encased. Joints in conduit shall be staggered so as not to occur side by side. Rigid non-metallic (PVC) conduit shall be connected to PVC coated rigid steel conduit at the point where it leaves the ground, with the transition to metal conduit occurring inside the concrete encasement. PVC coated rigid steel conduit may transition to non-coated conduit after exiting the encasement. The transition coupling between PVC coated conduit and non-coated conduit shall be PVC coated.

11. It is the general intent that boxes for light fixtures, switches, receptacles, etc. in or on the building be flush mounted with concealed conduit to the device, except in areas designated to have all conduit installed exposed.

12. All metal raceway systems shall be grounding conductive, solidly bonded throughout and grounded in accordance with NEC requirements and/or as noted on the Contract Drawings. In addition, all raceway systems shall be provided with separate grounding conductors.

13. **Minimum conduit size shall be 3/4 inch.** The following table shows the minimum burial depth required for all exterior conduit or cable:

Schedule 40 PVC, Concrete Encased	18"
Schedule 40 PVC, Concrete Encased (for medium voltage service entrance)	42"

14. Wire pulling shall be facilitated by the use of a UL approved pulling compound in pulls over 30 feet in length or where there are 2 or more 90 degree bends. Only polypropylene, nylon, or manila pulling ropes will be permitted. **Standard industry recognized wire pulling equipment shall be used.**

15. All conduits entering and leaving instrument enclosures shall be sealed around the wires with silicone caulk.

16. All conduits for emergency lighting systems shall be separate from other building power conduits.

17. Areas of use for each type of conduit:

Location	Schedule 40 PVC	Schedule 80 PVC	Aluminum	PCMC
Electrical Room – Exposed			X	
Pump Station and Wetwell			X	X
WWS			X	X
Diversion Structures			X	X
Valve Vault – Exposed Only			X	
Exterior Exposed			X	
Exterior Underground, Underslab, or In Slab	X	X		
Exterior Underground Service Entrance (Primary and Sec.)	X	X		

18. All conduit shall have an insulated ground wire pulled to all equipment and receptacles.

19. All raceway runs are shown diagrammatically to outline the general routing of the raceway. The installation shall be made to avoid interference with pipes, ducts, structural members or other equipment. Should structural or other interference prevent the installation of the raceways, or setting of boxes, cabinets, or the electrical equipment, as indicated in the Drawings, deviations must be approved by the Owner, and after approval, shall be made without additional charges and shown on the Record Drawings.

20. Assure conduit installation does not encroach into the ceiling height head room, walkways, or doorways.

21. Conduit may be run inside concrete slabs as long as the slab is at least 6-inches thick and conduit will have at least 1 2-inches of cover on both sides.

22. Runs of flexible conduit above accessible ceilings shall be limited to 10 ft. Runs of exposed flexible conduit shall be limited to 5 ft. All runs of flexible conduit shall be supported in accordance with NEC requirements.

23. All PVC coated conduit shall be installed in accordance with manufacturer's instructions. The Contractor shall use tools that are specifically suited for coated conduit systems. The use of pipe wrenches and other such tools on PVC coated RGS conduit is prohibited. The Engineer and Owner reserve the right to reject any installation of coated conduit that does not meet the requirements of the Section or the manufacturer's instructions. The Engineer and Owner also reserve the right to reject any installation that exhibits damage due to the improper use of tools. All rejected installations shall be replaced by the Contractor at no additional cost to the Owner. The use of PVC coated conduit repair compounds to repair damages or improper installation is prohibited.

24. All Contractor personnel that install PVC coated RGS conduit shall be trained by the PVC coated RGS conduit manufacturer. Training shall include proper conduit system

assembly techniques, use of tools appropriate for coated conduit systems, and field bending/cutting/threading of coated conduit. The Contractor shall furnish evidence of such training as specified herein. Training shall have been completed within the past 24 months prior to the Notice to Proceed on this Contract for all coated conduit installation personnel. Contractor personnel not trained within this timeframe shall not be allowed to install coated conduit, or shall be trained/re-trained as required prior to commencement of conduit installation.

25. Sealing fittings shall be installed where conduits pass from non-hazardous locations to hazardous locations and as required by Chapter 5 of the NEC. See section 16050 for hazardous area classifications.

END OF SECTION

SECTION 16131 - BOXES

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. Outlet and junction boxes shall be furnished and installed where indicated on the Contract Drawings, and\or as required by the work in accordance with the NEC.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Boxes – "Wiegmann," "Appleton," "Raco," "Crouse-Hinds," "Hoffman," "Robroy Industries," "Spring City," "Carlon," or equal.

2.02 GENERAL

A. All junction and/or pull boxes for dry (non-corrosive) areas shall be of code gauge sheet metal construction, of the inside dimensions as required by code, with covers.

B. Outlet boxes for wet or damp locations shall be cast metal, rust and corrosion resistant (NEMA 4X), with at least 5-1/2 full threads for each (bossed) conduit opening, and shall be suitable for flush or surface mounting as required with drilled external, cast mounting extensions (bossed to provide at least 1/8" between back of box and mounting surface for drainage). Box covers shall be hinged or cap screw retained as required, of the same material as the box and provided with stainless steel (rustproof) hardware.

C. Junction and/or pull boxes for out-of-doors use or indoor process areas, not mounted in concrete may be sheet metal (NEMA 4X), waterproof, rustproof, rain and sleetproof, with hinged covers and latches and provided means of locking by means of keyed locks, tamper-resistant screws or padlocking as required and with clamping cap-screws top and bottom door edges to provide firm contact with gasketing. All gaskets shall be molded (unbroken) neoprene or butyl rubber.

D. NEMA 4X junction and/or pull boxes may be stainless steel, if called for on the Contract Drawings; or non-metallic or cast aluminum.

E. Underground junction or pull boxes shall be constructed of reinforced concrete cast-in-place or pre-fabricated as detailed on the Contract Drawings.

F. Junction boxes for use in wet-wells and other hazardous areas shall be watertight, rustproof and corrosion resistant, and explosionproof with threaded conduit openings (5-1/2 full threads - minimum) and provided with rustproof hardware.

G. Explosionproof sealing fittings shall be furnished and installed in accordance with NEC requirements.

H. Junction and/or pull boxes for chemical storage and transfer areas shall be Schedule 80 PVC where Schedule 80 PVC conduit is specified in 16130.

PART 3 - EXECUTION

3.01 INSTALLATION, APPLICATION, AND ERECTION

A. General

1. Outlets shall be installed in the locations shown on the Contract Drawings. The Contractor shall study the general building plans in relation to the space surrounding each outlet, in order that his work may fit the other work required by these Specifications. When necessary, the Contractor shall relocate outlets so that when fixtures or other fittings are installed, they will be symmetrically located according to room layout and will not interfere with other work or equipment.

2. All supports for outlet boxes shall be furnished and installed by the electrical trades.

B. Concealed Work

1. All outlet boxes shall be standard galvanized steel type at least 2 inches deep, single or gang type of size to accommodate devices shown. Exceptions shall be noted on the Contract Drawings.

2. Standard deep type outlet boxes (concrete rings with appropriate covers) shall be used in floor slab construction so concealed conduits entering sides of boxes can clear reinforcing rods.

3. Outlet boxes for concealed telephone and signaling systems shall be the 4-inch square type, unless otherwise noted or required by the telephone company.

4. Boxes for use in masonry construction shall be 2-1/2 inches deep for 4-inch block and 3-1/2 inches deep for 6- and 8-inch block. Through wall boxes are prohibited for outlets opposite each other.

C. Exposed Work

1. Outlet or junction boxes for use with exposed aluminum conduit shall be copper free, cast aluminum type.

2. Outlet or junction boxes for use with exposed PVC conduit shall be PVC.

D. Pull Boxes

1. Pull boxes for exterior underground work are shown on the Contract Drawings and are the minimum number required. Others may be added at the Contractor's option, but no extra pay shall be allowed. Interior pull boxes are not shown but shall be used as needed. Pull box types are as follows:

   Exterior - Per detail on the Contract Drawings.

   Interior - Interior pull boxes in dry areas shall be of code gauge steel of not less than the minimum required by the NEC and shall be provided with hinged covers. In wet areas or pipe galleries, they shall be rated watertight, of stainless steel, cast aluminum, PVC, fiberglass, or equal. Hardware shall be stainless steel.

E. Openings in Electrical Boxes

1. All openings in electrical equipment, enclosures, cabinets, outlet and junction boxes shall be by means of welded bosses, standard knockouts, or shall be sawed, drilled, or

punched with tools specially made for the purpose. The use of a cutting torch is prohibited. Unused openings shall be plugged per the NEC.

END OF SECTION

SECTION 16140 - WIRING DEVICES

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. Wiring devices shall be installed where indicated on the Contract Drawings.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. "Hubbell," "Eagle," "General Electric," "Wiremold," "P&S," "Leviton," "Daniel Woodhead," or equal.

2.02 EQUIPMENT

A. Receptacles

1. Twin-convenience - outlet (interior) – "Hubbell" cat. no. 5362, or equal.

2. Twin-convenience - outlet (exterior) – "Hubbell" cat. no. 5362 with Taymac Corporation or Intermatic, Inc. safety outlet enclosure.

3. Special purpose outlet - Per equipment requirements.

4. Ground fault interrupting receptacles shall be required where shown on the Contract Drawings, and shall be indicated by the abbreviation "GFI" beside the circuit symbol on the Contract Drawings. They shall be rated 20 amps (125 volts) and shall be of the duplex, feed through type, capable of protecting all downstream receptacles on the same circuit. They shall be UL listed and interrupt the current between 4-6 milliamps of ground fault leakage. Appropriate plates shall be furnished and installed. The 20 ampere rating shall apply not only to device internals but to the faceplate as well.

B. Plates and Covers

1. Furnish and install plates of the appropriate type and size for all wiring and control devices, signal and telephone outlets.

2. All plates on flush and surface mounted boxes shall be of 302 stainless steel (nonmagnetic) with rounded or beveled edges, except where weatherproof covers are shown. All device plate screws shall be nylon or stainless steel with countersunk heads. Plates shall be installed vertically and with an alignment tolerance of 1/16 inch. Device plates shall be of the one-piece type, of suitable shape for the devices to be covered. Plates shall have a smooth finish with no crevices to collect dirt. Oversize plates are not acceptable.

3. Covers for boxes serving equipment where flexible conduit is to be tapped into cover plates shall be sheet metal drilled for conduit. Gaskets shall be required as well as all special adapters for mounting.

C. Wall Switches (Tumbler Type)

1. Single pole (interior) – "Hubbell" cat. no. 1221, or equal.

2. Single pole (exterior) – "Hubbell" cat. no. 1222, or equal, and Hubbell 1795 or equal plate.

3. 3-way switches (interior) – "Hubbell" cat. no. 1223, or equal.

4. 4-way switches (interior) – "Hubbell" cat. no. 1224, or equal.

5. Outside receptacles shall be labeled for the purpose.

PART 3 - EXECUTION

3.01 INSTALLATION/APPLICATION/ERECTION

A. Wall Switches

1. Wall switches shall be mounted at a height as indicated in Section 16050, unless otherwise noted on the Contract Drawings.

B. Receptacles

1. Outlets shall be located as shown on the Contract Drawings. Where located in special interior finishes, they shall be properly centered. Boxes shall be of the type noted and accepted for the specific installation.

2. Furnish and install receptacle circuits where called for on the Contract Drawings and/or by these Specifications. Circuits shall be installed in conduit from panel to receptacle, with flush mounted boxes except as noted on the Contract Drawings.

3. Receptacles and lighting circuits shall not be combined on the same overcurrent device. For runs over 75 feet or for 30 amp receptacles, minimum wire size shall be AWG No. 10.

4. Receptacles for specific devices (i.e., air conditioner), shall be rated at the correct voltage and amperage for that unit.

5. The minimum free length of conductor at each box for the connection of a fixture, switch or receptacle shall be 8 inches. All connections shall be made mechanically and electrically secure.

6. Receptacles shall be duplex type, rated at 20 amps, 125 volts, brown colored, unless otherwise noted. Mounting height shall be as specified for low outlets in Section 16050. All receptacles shall be of the grounding type.

7. Receptacles over workbenches or countertops or at medium or high mountings shall be mounted so that the grounding slot is below the neutral and hot. All other receptacles shall be mounted with the grounding slot above the neutral and hot.

8. Exterior weatherproof receptacles, shall be weatherproof while in use. This requirement shall apply on all outdoor units and on others as indicated on the Drawings. To meet this requirement, appropriate safety outlet covers as manufactured by Taymac Corporation, Intermatic Guardian Series, or equal shall be utilized in these areas.

END OF SECTION

SECTION 16150 - WIRE CONNECTIONS AND CONNECTING DEVICES

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. Wire connection and connecting devices shall be as herein specified.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Connectors, Lugs, etc. – "T & B", "Anderson", "Burndy", or equal.

B. Termination and splice connectors – "3M Scotchlok", "Anderson", "T & B", "Burndy", or equal.

2.02 MATERIALS

A. Wire Splicing and Terminations (600 Volts and Below)

1. Electrical Terminal and Splice Connectors (#22 - #4 AWG)

   a. Terminals and splice connectors from #22 - #4 AWG shall be compression types with barrels to provide maximum conductor contact and tensile strength. Performance, construction, and materials shall be in conformance with UL standards for wire connectors and rated for 600 volts and 105 degrees Celsius.

   b. Connectors shall be manufactured from high conductivity copper and entirely tin plated. Terminal barrels shall be serrated on the inside surface and have a chamfered conductor entry. Terminals shall have funnel entry construction to prevent strand fold-back. All barrels shall be brazed seam or seamless construction.

   c. Spade type terminals shall be sized for the appropriate stud and shall be locking type that snap firmly onto studs with a close fit for maximum retention. Spade type terminals shall be insulated with an insulation suitable for maintaining a high dielectric strength when crimped and be made form nylon, PVC, or equal.

2. Electrical Lugs and Connectors (#6 AWG - 1000 Kcmil)

   a. Lugs and splice connectors from #6 AWG - 1000 Kcmil shall be compression types with barrels to provide maximum conductor contact and tensile strength. They shall be manufactured from high conductivity copper and entirely tin plated. They shall be crimped with standard industry tooling. The lugs and connectors must have a current carrying capacity equal to the conductors for which they are rated and must also meet all UL requirements. All lugs above 4/0 AWG shall be 2 hole lugs with NEMA spacing. The lugs shall be rated for operation through 35 KV. The lugs shall be of closed end construction to exclude moisture migration into the cable conductor.

3. Twist-on Wire Connectors (#22 AWG - #10 AWG)

   a. All twist-on wire connectors must have a corrosion resistant spring that is free to expand within a steel jacket. The steel jacket must be insulated with a flexible vinyl jacket capable of withstanding 105 degrees Celsius ambient temperatures and of sufficient length to cover wires that are inadvertently overstripped.

b. Each connector size must be listed by UL for the intended purpose and color coded to assure that the proper size is used on the wire combinations to be spliced. The connectors must be compatible with all common rubber and thermoplastic wire insulations.

4. Solderless/re-usable lugs shall be used only when furnished with equipment such as control panels, furnished by others, where specification of compression type lugs is beyond the Contractor's control. In the event their use is necessary, the Contractor shall be responsible for assuring that they are manufactured to NEMA standards, with proper number and spacing of holes and set screws.

PART 3 - EXECUTION

3.01 INSTALLATION, APPLICATION, & ERECTION

A. Insulation of Splices and Connections

1. Connections/splices with a smooth even contour shall be insulated with a conformable 7 mil thick vinyl plastic insulating tape which can be applied under all weather conditions and is designed to perform in a continuous temperature environment up to 105 degrees Celsius. The tape shall have excellent resistance to abrasion, moisture, alkalies, acids, corrosion, and varying weather conditions (including sunlight). The tape shall be equal to Scotch 33+ and shall be applied in conformance with manufacturer's recommendations. In addition, it shall be applied in successive half-lapped layers with sufficient tension to reduce its width to 5/8 of its original width. The last inch of the wrap shall not be stretched.

2. Connections/splices with irregular shapes or sharp edges protruding shall be first wrapped with 30 mil rubber tape to smooth the contour of the joint before being insulated with 33+ insulating tape specified in the previous paragraph. The rubber tape shall be high voltage (69 KV) corona-resistant based on self-fusing ethylene propylene rubber and be capable of operation at 130 degrees Celsius under emergency conditions. The tape must be capable of being applied in either the stretched or unstretched condition without any loss in either physical or electrical properties. The tape must not split, crack, slip, or flag when exposed to various environments. The tape must be compatible with all synthetic cable insulations. The tape must have a dissipation factor of less than 5 percent at 130 degrees Celsius, be non-vulcanizing, and have a shelf life of a least 5 years. The rubber tape shall be applied in successive, half-lapped wound layers and shall be highly elongated to eliminate voids. Other manufacturer's recommendations on installation shall be adhered to. The rubber tape shall be equal to Scotch 23 or 130C electrical splicing tape.

3. Splices made in wet or damp locations shall be made submersible and watertight with special kits made for the application and compatible with type of cables employed.

B. Connection Make-up

1. Connections of lugs to bus bars, etc., shall be made up with corrosion resistant steel bolts having non-magnetic properties with matching nuts, and shall utilize a Belleville spring washer (stainless steel) to maintain connection integrity. Connections shall be torqued to the proper limits. Prior to bolting up the connection, electrical joint compound shall be brushed on the contact faces of the electrical joint.

2. All motor lead connections shall be made up to match the type of lead furnished on the motor. If the lead is not lugged, then twist-on wire connectors may be used. To prevent possible vibration problems, twist-on connectors shall be taped after installation.

3. All lugged motor lead connections (excluding motors over 200 horse-power) shall be made up using ring tongue compression lugs with proper size stainless steel nuts and bolts. Belleville type spring shall be used to maintain tension on the connections. The connections shall then be insulated using the procedure described for irregular shapes, utilizing rubber tape in conjunction with vinyl electrical tape.

4. At the time of final inspection, the Engineer may request the Contractor to disassemble 3 randomly selected motor lead connections in the Engineer's presence, to assure conformance with these Specifications.

5. The Contractor shall include all necessary tools, materials, and labor in his bid for disassembly of the connections and for remaking them with new insulating materials after inspection.

END OF SECTION

SECTION 16170 – SAFETY SWITCHES

PART 1 – GENERAL

1.01 SCOPE OF WORK

A. Provide horsepower-rated, quick-make, quick-break, safety switches provided with the number of poles and fuses as required.

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS/EQUIPMENT

A. Safety switches shall be as manufactured by General Electric, Square D Company, Eaton, or equal.

B. For 208- and 240-volt circuits, use general-duty type switches with Class R fuse clips. For 480-volt circuits, use heavy-duty type switches with Class R fuse clips.

C. Switches shall have arc shields, shall be of enclosed construction and fusible or non-fusible as indicated. Switches shall be rated for either 250-volt AC or 600-volt AC service as required.

D. All switches shall be capable of interrupting locked rotor current of motor which it serves.

E. Enclosures shall be NEMA-1 for interior non-process area use and NEMA-4X for exterior and process area use unless noted otherwise.

F. Provide dual-element Bussman type FRN (250 volt) or type FRS (600 volt) fuses for any fusible safety switch serving a motor circuit.

G. For non-motor loads, provide dual element Bussman type LPN (250 volt) or type LPS (600 volt).

H. All switches shall be capable of being padlocked in either the "On" or "Off" position.

I. Safety switches shall be provided with auxiliary contacts where indicated on Contract Drawings.

J. Safety switches shall be UL listed and shall conform to NEMA Standards. NEMA 4X enclosed safety switches where called for shall be stainless steel, or fiberglass.

K. NEMA 1 enclosed switches shall be phosphate coated as equivalent, code gauge steel with baked enamel finish.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Provide non-fusible switches at remote motor locations as indicated on drawings.

B. Provide fusible disconnects at package A/C units, fused as specified on unit nameplate.

C. Mount switches to walls or to equipment enclosures with a minimum of 4 bolts using toggle anchors for masonry construction, Phillips "Red Head" anchors for poured concrete

construction and bolts, jumbo washers, lock washers and nuts for equipment enclosure mounting.

D. All safety switches to be identified with nameplates per Section 16075.

END OF SECTION

SECTION 16220 - MOTORS

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. Motors are to be furnished with driven equipment except where otherwise noted on the Contract Drawings or elsewhere in this Division of the Specifications. All motors shall conform to the following Specifications and any special requirements of the driven equipment. Special requirements of the driven equipment shall take precedence over these Specifications should a discrepancy occur. Starting torque and slip ratings shall conform to the requirements of the driven equipment.

B. Polyphase motors shall be of the squirrel cage induction type and single phase of the capacitor start-induction run type except as otherwise noted. Conduit boxes shall be tapped for the size conduit shown on the Contract Drawings.

C. All motors shall be manufactured and installed in accordance with applicable NEMA standards and NEC provisions, latest revisions.

1.02 DELIVERY, STORAGE, & HANDLING

A. All electrical motors shall be protected against the accumulation of moisture, dust and debris and physical damage during the course of installation of the job.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Motors – "General Electric", "Westinghouse", "U.S. Motors", "Gould Century", "Lincoln", "Baldor", "Marathon", "Reliance", "Magnatek", "Siemens", or equal.

2.02 EQUIPMENT

A. Motors 200 Horsepower and Under for Service Under 600 Volts

1. Ratings and Electrical Characteristics

a. Time: All motors shall be rated for continuous duty.

b. Temperature: Based on NEMA standards for a maximum ambient temperature of 40 degrees Celsius and an altitude of 3,300 feet or less, according to service factor and insulation class employed.

c. Voltage: All single phase motors shall be rated 115/208/230 volts and all polyphase motors 230/460 volts. Submersible polyphase motors to be operated at 460 volts may take exception to the dual voltage requirement. All motors shall be capable of normal operation at balanced voltages in the range of ±10 percent from rated winding voltage.

d. Frequency: All a-c motors shall be rated for 60 Hz. operation. All motors shall be capable of normal operation at frequencies 5 percent above or below the nominal rating of 60 Hz.

e. Horsepower: Horsepower of the motors shall be as given in the Specification Division on the driven equipment or as shown on the Contract Drawings. Submersible motors shall be allowed to be furnished even though the horsepower rating may not be in accordance with standard NEMA assignments. In many cases, the horsepower specified is a minimum requirement and certain alternate manufacturers may require larger horsepower motors. The larger motor shall be furnished at no extra cost to the Owner.

f. Locked Rotor Current: Locked rotor current shall be in accordance with NEMA standards.

g. Efficiency and Power Factor: Efficiency and power factor shall be given consideration during Shop Drawing review. The ratings at full, 3/4, and 1/2 load shall be compared to similar motors manufactured by acceptable suppliers listed in these Specifications. Excessive variation shall be considered grounds for rejection.

h. Speed: Synchronous speed of motors shall correspond to standard NEMA ratings. Actual speed shall be as given in the Specification Division on the driven equipment. Slip shall not exceed 5 percent at full load.

i. Service Factor: The service factor shall be 1.15 unless requirements of the driven load necessitate a higher service factor. The service factor for inverter duty rated motors shall be 1.0.

j. Insulation Class: Insulation shall be NEMA Class F, except as otherwise noted. Submersible motors shall be Class F, and inverter duty motors to be operated at variable speed shall be Class H. Motors shall operate at a Class B rise at nameplate horsepower loading regardless of Insulation Class.

k. Design Level: Motors shall be NEMA design B, except as otherwise noted.

l. Enclosure: Motors for process equipment 2 HP and smaller shall be totally enclosed. All motors for process equipment larger than 2 HP shall be TEFC (totally enclosed fan cooled), suitable for use indoors or outdoors, except as otherwise noted. Totally enclosed non-ventilated (or air-over) motors may be used for ventilators and other auxiliary equipment that by virtue of the load are provided with more than adequate ventilation. ODP (open dripproof) motors may be used for ventilators where the motor is outside the air stream yet still protected from the weather. Division 15 of the Specifications and the HVAC Contract Drawings will detail the type of enclosure required for ventilators. Submersible motors shall be air or oil filled and of watertight construction. Motors used in classified atmospheres shall be properly rated for that hazard.

m. Frame Size: Frame designations shall be in accordance with NEMA standards.

n. Winding Overtemperature Sensors: All motors 15 horsepower and over shall be provided with motor winding thermostats. The devices shall be hermetically sealed, snap-acting thermal switches, actuated by a thermally responsive bi-metallic disk. A minimum of 1 per phase is required, with switches wired into the control circuit of the starter to provide deenergization should overheating threaten. All submersible motors shall be equipped with motor winding thermostats.

o. All submersible pump/motor assemblies shall be equipped to detect presence of moisture and alarm at the controller.

p. Motors specified for operation with variable frequency drives shall be inverter duty and shall be designed to output 100 percent of nameplate horsepower under continuous duty service without exceeding the temperature rise specified herein

when controlled by the actual drives furnished. Inverter duty motors shall be designed to operate down to 10% of full load speed without the need for a line powered cooling fan.

2. Mechanical Characteristics

   a. Integral Horsepower Motor Construction

      1) Motor frames for horizontal motors shall be cast iron, heavy fabricated steel, or cast aluminum (alloy 356 or 360). A steel insert ring shall be set into the aluminum alloy endshield when cast to minimize wear of the bearing support. **Aluminum alloy motors shall not be used in areas where exposed to chlorine gas.**

      2) Motor frames for vertical motors shall be cast iron, heavy fabricated steel, or extruded aluminum (alloy 6063-T4 or 6063-T6). Endshields for vertical motors **must** be cast iron.

      3) If an aluminum frame is used, the endshields and/or all other steel hardware must be plated with zinc or cadmium and coated with grease before assembly to minimize the galvanic action between the steel and aluminum.

      4) Motor frames and endshields shall be of such design and proportions as to hold all motor components rigidly in proper position and provide adequate protection for the type enclosure employed. Lifting lugs of all motors shall conform to NEMA standards.

      5) Windings shall be random or form wound, adequately insulated and securely braced to resist failure due to electrical stresses and vibration. If the windings are aluminum, there shall be a cold welded aluminum-copper transition joint at the termination of the windings to permit the use of standard copper to copper connection techniques by the electrician and to prevent galvanic action between the copper power wires and the aluminum windings.

      6) The motor shaft shall be made of high grade machine steel or steel forging of size and design adequate to withstand the load stresses normally encountered in motors of that particular rating. Bearing journals shall be ground and polished.

      7) Rotors shall be made from high grade steel laminations adequately fastened together and to the shaft. Rotor cage windings may be cast aluminum of bar type construction with brazed end rings.

      8) Integral horsepower motors shall be equipped with cone, roller, or ball bearings made to AFBMA standards, Grade 1 and shall be of ample capacity for the motor ratings. The bearing housing shall be large enough to hold sufficient lubricant to minimize the need for frequent relubrication (ten years normal operation without lubrication), but facilities shall be provided for adding new lubricant and draining out old lubricant without motor disassembly. The bearing housing shall have long, tight running fits or rotating seals to protect against the entrance of foreign matter into the bearings or leakage of lubricant out of the bearing cavity.

      9) See the specification division relating to each piece of motor driven equipment for additional motor requirements to those listed above.

   b. Fractional Horsepower Motor Construction

      1) Motor and shell shall be rigid welded steel designed to maintain accurate alignment of motor components and provide adequate protection. End shields shall be reinforced, lightweight, die cast aluminum. Windings shall be of varnish

insulated wire with slot insulation of polyester film and baked on bonding treatment to make the stator winding strongly resistant to heat, aging, moisture, electrical stresses, and other hazards. Motor shafts shall be made from high grade, cold rolled, shaft steel with drive shaft extensions carefully machined to standard NEMA dimensions for shaft coupled drive connection. Bearings shall be carefully selected precision ball bearings with extra quality, long life grease and large reservoir providing 10 years normal operation without relubrication, AFBMA Grade 1.

c. Submersible Motor Construction

1) See Equipment Specifications.

3. Tests, Nameplates, and Shop Drawings

a. Tests

1) Tests shall be required on integral horsepower motors only. A factory certified test report of "electrically duplicate motors previously tested" shall be supplied on all motors under 200 horsepower. The test shall be certified by the factory and shall contain a statement to the effect that complete tests affirm the guaranteed characteristics published in the manufacturer's catalogs or descriptive literature.

2) Tests will be in accordance with IEEE test procedures.

b. Nameplates

1) Each motor shall have a permanently affixed nameplate of brass, stainless steel, or other metal of durability and corrosion resistance. The data contained on the nameplate shall be in accordance with NEMA standards.

c. Shop Drawings

1) Shop Drawings shall consist of motor dimensions, nameplate data from each motor and tests as outlined above. Also included shall be efficiency and power factor at 100, 75, and 50 percent load. Operation, maintenance, and lubrication information (including bearing catalog numbers) shall be submitted with Shop Drawings for review.

4. Efficiency Requirements

a. The following motor full load efficiency requirements shall be met as a minimum for totally enclosed 3 phase integral horsepower motors, per NEMA test methods:

Horsepower	**Nominal 3600 RPM (Minimum %)**	**Nominal 1800 RPM (Minimum %)**	**Nominal 1200 RPM (Minimum %)**
1	75.5	82.5	80.0
1.5	82.5	84.0	85.5
2	84.0	84.0	86.5
3	85.5	87.5	87.5
5	87.5	87.5	87.5
7.5	88.5	89.5	89.5
10	89.5	89.5	89.5
15	90.2	91.0	90.2
20	90.2	91.0	90.2

Horsepower	Nominal 3600 RPM (Minimum %)	Nominal 1800 RPM (Minimum %)	Nominal 1200 RPM (Minimum %)
25	91.0	92.4	91.7
30	91.0	92.4	91.7
40	91.7	93.0	93.0
50	92.4	93.0	93.0
60	93.0	93.6	93.6
75	93.0	94.1	93.6
100	93.6	94.5	94.1
125	94.5	94.5	94.1
150	94.5	95.0	95.0
200	95.0	95.0	95.0

Open Motors where specified shall also comply with NEMA efficiency minimums.

b. Motors shall be energy efficient type to comply with requirements of the Energy Policy Act of 1992.

B. Motors Over 200 Horsepower for Service Under 600 Volts

1. Motors specified in this section shall comply with the requirements of preceding Section 2.02, Sub-article A unless otherwise noted herein. Motors shall be furnished by the pump supplier to be installed by the Contractor.

2. Motors shall be especially suitable both electrically and mechanically to drive the equipment specified in other divisions. The speed, horsepower, torque, base, bearings, shaft and motor tolerances shall be coordinated closely with the equipment manufacturer's requirements so as to provide a satisfactory, efficient drive without overloading, overheating, or abnormal vibration.

3. Motors shall meet the NEMA temperature rise as defined for Class F insulation. Service factor shall be 1.15 and the motor shall be tested for temperature rise at its service factor load above a 40°C ambient. All motors shall be dynamically balanced and vibration shall be measured per NEMA methods. Critical speed of the shaft and motor assemble shall be above the operating speed of the motor by at least 10 percent.

4. Motors shall be equipped with nonreverse ratchets to prevent damage to pumps.

5. Bearings shall be selected to have AFBMA rated minimum life of 1 year when operating continuously at rated speed of the motor and at total load consisting of the weight and hydraulic thrust load imposed on the motor by the pump. Angular contact ball thrust bearings, spherical roller thrust bearings, or plate thrust bearings shall be used depending on thrust requirements. Motors shall have oil lubricated thrust and guide bearings, with visual level indicators, accessible drain plugs and accessible filling plugs. Oil lubrication system shall be so designed as to provide the correct quantity of lubricant with minimum foaming or aeration. A nameplate shall be provided on all motors showing bearing numbers and oil type and required viscosity.

6. Motors shall be high thrust capable of carrying 30 percent momentary upthrust.

7. In addition to the test report required in the preceding Sub-article, the manufacturer shall submit data indicating: guaranteed efficiencies and power factor at 100 percent, 75 percent, and 50 percent load; full load current; locked rotor current.

PART 3 - EXECUTION

3.01 INSTALLATION/APPLICATION/ERECTION

A. Installation of motors shall comply with motor manufacturer's instructions as well as applicable NEMA recommendations and requirements of the driven equipment OEM (original equipment manufacturer).

B. Motors shall be aligned to acceptable tolerances and shall not vibrate excessively.

C. Motors shall not be energized until they have been accepted by the OEM start up personnel.

END OF SECTION

SECTION 16270 - TRANSFORMERS

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. Transformer locations, sizes, connections and voltage/phase shall be as shown on the Contract Drawings, furnished and installed as herein specified.

B. All transformers shall have the KVA rating painted on the exterior in a contrasting color to the enclosure paint color, in a size large enough to be read from a distance (minimum 6" high letters), or from the ground in the case of pole-top units.

C. All transformers shall be non-PCB type.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. "Cooper", "Square D", "Eaton", "General Electric", or equal.

2.02 FABRICATION

A. Oil Filled Transformer

1. General

   a. Oil type transformers shall not make use of oil containing PCB.

2. Pad-mounted, Tamper-proof, Compartmental Type, Mineral Oil Insulated, Self-cooled Transformer

   a. The transformer shall be compartmental type, self-cooled, tamper-resistant and weather protected. The transformer shall have a bolted cover with tamper-resistant fastenings. Lifting eyes and jacking pads shall be provided. The tap changing mechanism shall be externally operable and for de-energized operation only. The high and low voltage compartments shall be side by side, separated by a steel barrier with the low voltage on the right. Access to the high voltage compartment cannot be made until the low voltage door has been opened. Doors shall be equipped with lift-off stainless steel hinges and door stops.

   b. A removable front sill will allow the transformer to be rolled or skidded. High voltage terminations shall be deadfront-externally clamped one piece integral bushings for loop feed operation. Low voltage bushings shall be molded epoxy with blade type spades. The transformer shall comply with the latest applicable standards of NEMA and ANSI.

   c. Additional characteristics and optional features:

Primary Voltage:	12470, Delta
Taps:	± 2 - 2 1/2 percent
BIL:	95
Impedance:	4 - 6 percent
Temperature Rise:	55°C/65°C above a 30°C ambient
Coolant:	Oil

Fill plug and pressure relief valve

Oil level plug
Lightning arresters, deadfront (elbow type for installation on unused loop feed bushings)
Fusing: ELSP partial range current limiting with expulsion bayonet
No load tap changer - externally operable
Drain valve and sampling device
Gang operated load break switch (under oil)
Paint: Manufacturer's standard
Windings: Copper

d. Concrete pad details are shown on the Contract Drawings. Should the transformer offered not fit on the designed pad; cost of modifications and larger pad shall be borne by the Contractor.

PART 3 - EXECUTION

3.01 INSTALLATION/APPLICATION/ERECTION

A. Transformers shall be furnished and installed in accordance with manufacturer instructions, NEC, and NESC requirements, as well as local utility company requirements.

B. Touch up paint on exterior of enclosure.

C. Anchor to foundation.

END OF SECTION

SECTION 16280 – SURGE PROTECTIVE DEVICES

PART 1 - GENERAL

1.01 REQUIREMENTS

A. The Contractor shall furnish, install, and place in satisfactory operation, the surge protective devices (SPD) as specified herein.

B. Surge protective devices shall be provided as a stand-alone unit, separate from the enclosure of the equipment to which they are connected or as integrally mounted devices as noted on the Contract Drawings.

1.02 CODES AND STANDARDS

A. The surge protective device shall be designed, manufactured, and listed to the following standards:

1. Underwriters Laboratories, Inc. (UL)

   a. UL1449 3rd Edition: Surge Protective Devices

   b. UL1283 5th Edition: Electromagnetic Interference Filters

2. American National Standards Institute (ANSI)/Institute of Electrical & Electronic Engineers (IEEE)

   a. C62.41.1: 2002 Guide for Surge Voltages in Low-Voltage AC Power Circuits

   b. C62.41.2: 2002 Recommend Practice on Characterization of Surges in Low Voltage (100V and Less) AC Power Circuits.

   c. C62.45: 2002 IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000V and Less) AC Power Circuits

   d. C62.62: 2000 IEEE Standard Test Specifications for Surge Protective Devices for Low Voltage (1000V and Less) AC Power Circuits

3. National Electric Code (NEC), Latest Edition

1.03 TESTING

A. All tests shall be performed in accordance with the requirements of the General Conditions and Division 1. The following tests are required:

1. Witnessed Shop Tests

   a. None required.

2. Certified Shop Tests and Reports

   a. Standard factory tests shall be performed on the equipment under this section. All tests shall be in accordance with the latest version of NEMA, ANSI, and UL standards.

b. All surge protective devices, subassemblies, and components shall be 100% tested and certified by the manufacturer to meet their published performance parameters.

3. Field Tests

a. None required.

1.04 SUBMITTALS

A. The Contractor shall obtain from the equipment manufacturer and submit the following per Section 01300:

1. Shop Drawings
2. Operation and Maintenance Manuals
3. Spare Parts List
4. Special Tools List
5. Reports of ShopTests

1.05 SHOP DRAWINGS

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

B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for re-submittal.

C. Drawings submitted by the manufacturer shall be complete and documented to provide the Owner with operations and maintenance capabilities.

D. Shop drawings for each SPD shall include but not be limited to:

1. Product Data Sheets.
2. Detailed drawings showing weights and dimensions.
3. Wiring diagrams showing field connections.
4. Proof that all products provided under this Section are UL listed and labeled by Underwriters Laboratories to UL1449 3rd Edition. This proof shall be a copy of the data listed under the UL File Number for the manufacturer, which may be obtained from the UL Online Certification Directory. No other means of proving compliance (such as manufacturer data sheets, marketing material, etc) will be considered acceptable.
5. Proof of Short Circuit Current Ratings (SCCR), Voltage Protection Ratings (VPRs) for all modes, Maximum Continuous Operating Voltage rating (MCOV), Nominal Discharge Current (In), and device listing Type shall be submitted using the same means as described in the paragraph above.
6. Proof that all products provided under this Section are UL listed and labeled by Underwriters Laboratories to UL 1283 5th Edition. This proof shall be a copy of the data listed under the UL File Number for the manufacturer, which may be obtained from the

UL Online Certification Directory. No other means of proving compliance (such as manufacturer data sheets, marketing material, etc) will be considered acceptable.

7. Warranty Information

E. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these Specifications are being met. Copies of technical bulletins, technical data sheets from "Soft Cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items the Contractor intends to provide are to provide are acceptable and shall be submitted.

1.06 OPERATION AND MAINTENANCE MANUALS

A. The Contractor shall submit operation and maintenance manuals.

1.07 TOOLS, SUPPLIES, AND SPARE PARTS

A. The SPDs and accessories shall be furnished with all special tools necessary to disassemble, service, repair, and adjust the equipment. All spare parts as recommended by the equipment manufacturer shall be furnished by the Contractor to the Owner.

B The Contractor shall furnish one (1) spare field replacement module of each rating provided under this Contract.

C. The spare parts shall be packed in containers suitable for long term storage, bearing labels clearly designating the contents and the pieces of equipment for which they are intended.

D. Spare parts shall be delivered at the same time as the equipment to which they pertain. The Contractor shall properly store and safeguard such spare parts until completion of the Work, at which time they shall be delivered to the Owner.

E. Spare parts lists, included with the shop drawing submittal shall indicate specific sizes, quantities, and part numbers of the items to be furnished. Terms such as "1 lot of packing material" are not acceptable.

F. Parts shall be completely identified with a numerical system to facilitate parts inventory control and stocking. Each part shall be properly identified by a separate number. Those parts which are identical for more than one size, shall have the same part number.

1.08 IDENTIFICATION

A. Each SPD shall be identified by equipment name. A nameplate shall be securely affixed in a conspicuous place on each SPD.

1.09 TRAINING

A. The Contractor shall provide training for Owner personnel. Training shall be conducted by the manufacturer's factory trained specialists who shall instruct Owner personnel in operation and maintenance of all equipment provided under this Section. The training shall also include an overview of current SPD standards, as well as basic SPD operation and maintenance.

B. Provide the services of an experienced, factory trained technician or service engineer of the SPD manufacturer at the jobsite for minimum of 1/2 day for training of Owner personnel, beginning at a date mutually agreeable to the Contractor and the Owner.

1.10 WARRANTY

A. All SPDs, associated hardware, and supporting components shall be warranted to be free from defects in materials and workmanship, under normal use and in accordance with the instructions provided, for a period of five (5) years after acceptance of the equipment by the Owner.

B. Any component or subassembly contained within the surge protection system that shows evidence of failure or incorrect operation during the five (5) year warranty period, shall be replaced and reinstalled by the manufacturer at no additional cost to the Owner.

PART 2 - PRODUCTS

2.01 GENERAL

A. The SPD shall be UL 1449 3rd Edition Listed and must bear the 3rd Edition mark. Units that are "manufactured in accordance with" UL 1449 3rd Edition or tested by other testing agencies "in accordance with" UL 1449 3rd Edition are not acceptable and will be rejected.

B. The SPD shall be UL 1283 5th Edition Listed and must bear the UL mark. Units that are "manufactured in accordance with" UL 1283 5th Edition or tested by other testing agencies "in accordance with" UL 1283 5th Edition are not acceptable and will be rejected. Further, SPD units using UL 1283 capacitors but not tested to UL 1283 will be rejected.

C. SPDs shall be provided as a stand-alone unit, separate from the equipment to which they are connected.

D. All SPDs furnished and installed under this Contract shall be from the same manufacturer.

2.02 PRODUCTS

A. Type I surge protective devices (SPD) shall be furnished and installed. Type II SPDs are not acceptable.

B. Each SPD shall be rated for the voltage and configuration of the equipment to which it is connected.

C. Each SPD shall have UL 1283 5th Edition EMI/RFI filtering with minimum attenuation of -50dB at 100kHz.

D. The short circuit current rating of each SPD shall match or exceed the rating of the equipment to which it is connected. The Contractor shall reference the Pump Station Schedule for short circuit current rating of each piece of equipment.

E. Each SPD system shall provide surge protection in all possible modes. Surge protection shall be as follows:

SYSTEM CONFIGURATION	MODES OF PROTECTION	NUMBER OF MODES
3-Phase Wye	L-N, L-G, N-G	7
3-Phase Delta	L-L, L-G	6
3-Phase Impedence Grounded	L-L, L-G	6
Single-Phase	L-N, L-G, N-G	3

F. Each SPD shall have a Maximum Continuous Operating Voltage (MCOV) of at least 115% of the nominal voltage of the equipment to which it is connected.

G. The Nominal Discharge Current (I_n) of each SPD shall be 20kA. Peak surge current ratings shall not be used as a basis for applying the SPD to the system.

H. The Voltage Protection Rating (VPR) of each SPD shall not exceed the following:

SYSTEM VOLTAGE	L-N	L-G	L-L	N-G
208Y/120	700V	700V	1200V	700V
480Y/277	1200V	1200V	1800V	1200V
480 DELTA	N/A	1200V	2000V	N/A
240 DELTA	N/A	1200V	1200V	N/A
120/240	700V	700V	1200V	700V

I. The surge current rating for each SPD shall be as indicated on the Contract Drawings. Surge current rating indicated is on a per phase basis.

J. Each SPD shall be provided in an enclosure to match or exceed the NEMA rating of the equipment enclosure that it is serving (i.e. NEMA1, NEMA 12, NEMA 4X, etc).

K. Each SPD shall be provided with the following accessories:

1. Each individual module shall feature an LED indicating the individual module has all surge protection devices active. If any single component is taken off-line, the LED shall turn off and another LED shall illuminate, providing individual module as well as total system status indication.

2. Surge counter and audible alarm with reset/silence switch.

3. One set of Form C (SPDT) dry contacts rated for at least 5A at 120VAC.

L. SPDs shall be as manufactured by Eaton Electrical, Thor Systems, Advanced Protection Technologies (APT), or LEA International.

PART 3 - EXECUTION

3.01 INSTALLATION

A. The SPD units shall be furnished and installed in accordance with the manufacturer's installation instructions. One (1) copy of these instructions shall be included with the equipment at time of shipment.

B. The SPD units shall be mounted such that the conductor lengths are as short as possible, but no greater than 36 inches. Any installation resulting in a conductor length of greater than 36 inches shall be reviewed with the Engineer as a special type of cable may need to be installed. For equipment such as panelboards, the Contractor shall relocate the circuit breaker that is to be connected to the SPD as needed to achieve the shortest conductor length possible.

C. The Contractor shall use a close nipple to enclose the conductors between the SPD and the equipment served. However, if due to field conditions a 90 degree conduit bend is required to connect the SPD to the equipment that it serves, the bend shall have a minimum radius of 36 inches to eliminate any potential for sharp bends in the conductors.

D. Conductors between the equipment served and the SPD shall be 600V power wire and cable as specified in Section 16120 – Conductors and Cables. The individual conductors shall be gently twisted.

E. Prior to energizing, the Contractor shall verify that the SPD unit voltage and configuration is suitable for the system to which it is connected.

F. Prior to energizing, the Contractor shall also verify that any Neutral to Ground bonding jumpers are installed as required.

G. Prior to energizing, the Contractor shall also verify that the impedence of the equipment grounding conductor between the SPD and the grounding electrode system is less than 1 ohm.

END OF SECTION

SECTION 16312 - UNDERGROUND MEDIUM VOLTAGE POWER DISTRIBUTION

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. The underground power distribution system shall be installed in accordance with NEC and NESC requirements, and as written herein and as shown on Contract Drawings. For further information on components/installation not addressed in this article, refer to other sections of this Division, and the Contract Drawings.

B. Ends of conduits shall be sealed where they enter buildings at service equipment and empty (spare) conduits shall be capped at both ends. Spare conduits shall extend 5 feet from buildings or structures unless otherwise shown on the Contract Drawings.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Conduit

1. Underground nonmetallic conduit shall be Carlon, George-Ingraham, Ciba-Geigy, or equal. Other types of conduit for transitions to building interiors, etc., shall be as specified in 16130 - Raceways.

B. Duct Spacers and Terminators

1. Duct spacers and terminators shall be Formex, or equal.

C. Medium Voltage Insulated Power Cables

1. Medium voltage insulated power cables shall be Okonite, Anaconda, or equal.

D. Prefabricated Splice Kits and Terminations

1. Prefabricated stress cones, shield grounding adapters, splice kits, and terminations shall be as manufactured Elastimold, 3M, Cooper, G&W, or equal.

2.02 MATERIALS

A. Conduit

1. Underground duct lines for medium voltage shall be fiberglass duct or PVC, concrete encased.

B. Duct Spacers and Terminators

1. Spacers shall be made from high density polyethylene, and shall be double wall construction. They shall consist of interlocking modules, i.e. bases, intermediates and caps. Base pads shall be used to assure specified dimensions between trench floor and bottom of first tier of ducts. The interlocking modules shall include an internal vertical channel on both side edges of the spacers. The interlocking module spacers shall provide independent support for each duct, and 3 inch separation between ducts.

2. Terminator modules shall be made from high impact, high strength, prime virgin acrylonitrile butadiene styrene (ABS) plastic, Marbon Type G.S., or equal. Terminator module shall interlock and be sealed together using a recommended plastic solvent cement. The openings of the terminator facing the inside of the manhole shall be belled.

C. Medium Voltage Insulated Power Cables

1. 5 and 15 KV cables shall have the following specifications:

Conductor:	Uncoated copper, stranded
Cable Arrangement:	Single conductor
Strand Screen:	Extruded, semi-conducting
Insulation:	5 KV cable 115 mils EPR 15 KV cable 220 mils EPR
Insulation Screen:	Extruded, semi-conducting
Shield:	Uncoated copper tape, helically wrapped, 12.5% overlap
Jacket:	PVC
Temperature Rating:	105EC continuous 140EC emergency 250EC short circuit

D. Prefabricated Splice Kits and Terminations

1. Molded Rubber Shielded Cable Splice

a. The shielded cable splices must be capable of normal continuous operation at the rated voltage and current on the cable on which it is to be used (up to 35 KV). The splice must consist of an all-molded rubber splice body with black semi-conductive EPR rubber. All EPR rubber must be cured with a peroxide cure. All splices must be able to be installed without the use of mechanical advantage installation tools. Where required, shield adapters must be capable of quickly extending the cable shielding for outdoor, indoor, and buried applications.

2. Molded Rubber Cable Termination

a. The shielded cable termination must be capable of normal continuous operation at the rated voltage and current on the cable it is to be used on (up to 35 KV); and it should meet all the requirements of a Class 1 Termination as given in IEEE Standards. The termination must consist of a high quality rubber molded stress cone made of track resistant peroxide cured EPR rubber and a one-piece silicone rubber skirted insulator for 15 KV (two-piece silicone skirted insulator for 25 and 35 KV). A mechanical (non-solder) ground strap assembly shall be included as a part of the kit. All materials (except lug) necessary to make three terminations shall be included as part of the basic 5 to 15 KV kit. This should include cable preparation materials. Additional materials may be necessary in order to convert the basic 5 to 15 KV kit into a 25 or 35 KV termination; however, the instructions packed with the kit should include all of the information as to what is needed for 25 and 35 KV.

3. Shield Grounding Adapter

a. The shield ground adapter must be capable of use at the rated voltage of the cable it is used on, and shall be totally mechanical, requiring no soldering or taping. It shall be watertight. The housing shall be molded

conductive rubber. The ground lead shall be copper. Contact with the cable shield shall be by compression of a corrugated internal contact. Compression shall be accomplished by external stainless steel clamp(s).

4. Load break and Dead break Elbow Connectors and Accessories

a. Insulated high voltage cable shall be terminated using dead front elbows at pad mount transformers. 200 Ampere elbows shall be load break and 600 ampere elbows shall be dead break. Voltage class shall be 15 KV. The insulating elbows shall be molded of EPDM rubber with integral stress cones. The 200 ampere devices shall accept No. 6 - No. 4/0 conductors and the 600 ampere devices shall accept No. 2/0 - 1000 MCM conductors. Both type connectors shall be watertight and shall include all accessories needed for connection to conductor. Other characteristics:

Impulse Voltage:	95 KV BIL
Withstand Voltage:	34 KV, 60 Hz., 1 Minute
Minimum Corona Extinction Level:	11 KV
Momentary:	10,000 amps RMS Symmetrical

b. Cable shield grounding adapters shall be furnished and installed as needed. Necessary bushing shall be furnished and installed in switches and transformers for proper mating with the elbow connectors. Feed through bushings shall be used at transformers so that dead front arresters may be connected to the unused feed through bushing.

c. The dead front arrestor shall be gapless, of solid state design using a metal oxide varistor enclosed in a molded elbow similar to the elbow connector housing.

d. Furnish insulated protective caps where needed to maintain the dead front, watertight arrangement where a bushing is unused.

PART 3 - EXECUTION

3.01 INSTALLATION/APPLICATION/ERECTION

A. Duct

1. General

a. The duct system shall consist of single or multiple round-bore conduit for the electrical-distribution system. The number and size of the ducts shall be as indicated on the Contract Drawings. Duct lines shall be laid to a minimum grade of 4 inches per 100 feet. Duct shall be laid so that the top of the duct is 36 inches below finished grade or finished paving (or as shown in duct bank details on the Drawings). Changes in direction of runs exceeding a total of 10 degrees, either vertical or horizontal, shall be accomplished by long sweep bends having a minimum radius of curvature of 25 feet, except that manufactured bends may be used at the ends of the run. The long sweep bends may be made up of one or more curved or straight sections and/or combinations thereof. Manufactured bends shall have a minimum radius of 18 inches for use with ducts of less than 3 inches in diameter and a minimum radius of 36 inches for ducts of 3 inches in diameter and larger. Conduits shall terminate in end bells where duct lines enter manholes. Conduit shall be thoroughly

cleaned before using or lying. During construction and after the duct line is completed, the ends of the conduit shall be plugged to prevent water washing mud into the conduits or manholes. Particular care shall be taken to keep the conduits clean of concrete, dirt and any other substance during the course of construction.

b. Where it is necessary to cut a tapered end on a piece of conduit at the site, the cut shall be made with a tool or lathe designed to cut a taper to match the taper of the particular conduit being used. After the duct line has been completed, a standard flexible mandrel not less than 12 inches long, having a diameter approximately 1/4 inch less than the inside diameter of the conduit, shall be pulled through each conduit, after which a brush with stiff bristles shall be pulled through each conduit to make certain that no particles of earth, sand, or gravel have been left in the line. Pneumatic rodding may be used to draw in the lead wire. Where connection is made to an existing duct that is of different material and shape than the duct line being installed, a suitable coupling of a type recommended by the duct manufacturer shall be used. Conduits shall be stored to avoid warping or deterioration. Plastic conduit shall be stored on a flat surface and protected from the direct rays of the sun. Conduit joints in concrete encasement may be placed side by side horizontally but shall be staggered at least 6 inches vertically.

c. Each single conduit of the duct bank shall be completely encased in concrete if indicated on the Contract Drawings. The thickness of the concrete encasement indicated is the minimum thickness, and may be increased to fit the actual shape of the trench. Duct spacers shall be used placed on 4 feet centers. When the duct bank is assembled, a No. 3 reinforcing rod shall be passed through the internal vertical channels on one side of the spacer bank and driven into the trench floor. At the next spacer location, the No. 3 rod shall be inserted on the opposite side, etc. The reinforcing rods shall be bent inwardly at the top of the spacer bank sufficiently to squeeze the spacer cap so the duct assembly will not float or move in any direction during the concrete pour. Concrete encasement shall not be less than 3 inches on the side, bottom, and top of the conduits.

2. Couplings

a. Joints in conduit shall be made up in accordance with the manufacturer's recommendations for the particular conduit and coupling used. The plastic or fiberglass conduit joints shall be made up by brushing a plastic solvent cement or epoxy (as applicable) on the inside of the coupling and on the outside of the conduit ends. The conduit and fitting shall then be slipped together, until seated, with a slight twist to set the joint tightly, and the conduit then rotated 2 turn to distribute the cement evenly. Excess cement build up on the inside surface of the conduit shall then be removed.

B. Manholes

1. Manholes shall be installed at locations shown on the Contract Drawings. Details of construction shall be as shown on the Contract Drawings as well, and construction shall conform to requirements as written elsewhere on concrete and manholes. A cable pulling iron shall be installed in the wall opposite each duct line entrance if necessary. Manholes shall be arranged to drain.

C. Medium Voltage Insulated Power Cable Systems

1. The power cable systems shall consist of ethylene-propylene rubber insulated PVC jacketed conductors. The size and number of conductors shall be as indicated on the Contract Drawings. Conductors shall be stranded. Cables for use on 4,160 volt power systems shall be rated 5,000 volts and cables for use on 12,470 volt power systems shall be rated 15,000 volts. Cables shall be insulated to the 133 percent level. The neutral conductors of grounded neutral systems shall consist of stranded 600 volt polyethylene jacketed cables suitable for direct burial or duct shown on the Contract Drawings. Power cables shall be installed in duct lines as specified this section.

2. It is intended that cables be continuous as much as is practical without unnecessary splices. Cable splices, however, shall be made in manholes or junction boxes if necessary, and shall be installed at no extra cost to the Owner. Cable splices and terminations shall be made up in accordance with cable manufacturer recommendations, by persons qualified to make such splices/terminations. Qualification shall consist of proof that the person(s) working on splices and terminations has at least 3 years experience with the type cables and connectors encountered on this project.

3. Cable pulling shall be accomplished using industry recognized pulling equipment and techniques, and shall be done in accordance with cable manufacturer's recommendations. All cable shields shall be grounded at both ends.

D. Prefabricated Splice Kits and Terminations

1. Splices and terminations shall be of a type appropriate for the cable type and for the environment encountered, either indoor or outdoor. All kits shall include premolded stress cones and all necessary materials needed for proper installation. The Contractor shall furnish necessary lugs, etc. for mechanical hookup from cables to equipment.

2. All terminations and splices shall be installed in accordance with manufacturer recommendations and shall be complete with all necessary accessories for an operational system. All terminations and splices shall be made prior to cable Hipot testing. All lightning arresters shall be properly grounded. All terminations in outdoor cabinets shall be treated as outdoor and terminated accordingly.

3.02 FIELD QUALITY CONTROL

A. A DC Hipot test shall be conducted on all cables before hookup and after pulling, when the cables are fitted with all terminating and splicing kits. Testing shall be in accordance with IEEE and manufacturer recommendations with test voltage for each cable as advised by the manufacturer. All cable shields shall be grounded during testing and ends of cables under test adequately insulated from grounded equipment and other equipment not under test. Submit a written report of test results to the Engineer on all cables.

B. Prior to Hipot testing, the Contractor shall utilize a high voltage megger to detect gross insulation system failure. The Hipot test on a very low quality insulated cable is destructive, and screening the cables first with the megger may prevent the Contractor replacing an otherwise salvageable cable.

C. Hipot testing shall also be performed on existing cables which have been disturbed during the course of this work.

END OF SECTION

SECTION 16315 - PRIMARY GROUNDING

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. Grounding shall conform to applicable requirements in the NEC and NESC and as written elsewhere in these Specifications. Neutral conductors, cable shields, metallic conduits, termination bodies, junction boxes, lightning arrestors, fences and all non-current carrying metallic parts of equipment, shall be grounded. Ground rods shall be copper or copper-clad steel, 3/4 inch minimum diameter, at least 10 feet long, driven fully into the earth.

B. Grounding electrodes at transformers and sectionalizing switches shall have a ground resistance not to exceed 5 ohms. Ground resistance shall be measured not less than 48 hours after rainfall. A bare copper cable not smaller than No. 4/0 AWG shall be installed not less than 30 inches below grade connecting to the indicated ground rods. Fence and equipment connections shall not be smaller than No. 4 AWG. Fences shall be grounded at every gatepost and corner post. Each gate section shall be bonded to the fencepost with a flexible braided copper grounding strap. Transformer neutral connections shall not be smaller than 1/0 AWG. Where rated secondary current exceeds 400 amperes, the size of the neutral ground connection shall be increased to not less than 2 of the area of secondary phase conductors. Where measured ground resistance exceeds 5 ohms, additional rods shall be driven, not less than 10 feet apart, connected with 4/0 cable, until proper resistance is achieved (50 foot total rod length maximum).

C. All concealed or buried grounding system connections or grounding electrode connection shall be of the exothermic weld type.

D. Lightning arrestor grounding conductors shall be separate from other grounding conductors, but shall be bonded to the neutral or to the equipment ground where such ground exists within 50 feet.

E. All grounding electrodes at transformers and lightning arrestors shall be tested for conformance to the 5 ohm value and the procedure shall be the same as described in Section 16060 on secondary grounding.

PART 2 - PRODUCTS

Not Applicable.

PART 3 - EXECUTION

Not Applicable.

END OF SECTION

SECTION 16370 - OVERHEAD MEDIUM VOLTAGE POWER DISTRIBUTION

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. This specification covers the requirements for aerial electrical distribution systems using wood poles.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. See Electrical Section 16050, Basic Electrical Materials & Methods for general requirements relating to electrical work performer under this contract.

B. See Electrical Section 16315, Primary Grounding for grounding of aerial electrical distribution systems.

1.03 SUBMITTALS

A. Catalog cuts, brochures, circulars, specifications, product data, and printed information in sufficient detail and scope to verify compliance with the requirements of the contract documents shall be submitted.

B. A complete itemized listing of equipment and materials proposed for incorporation into the work shall be submitted. Each entry shall include the item number, the quantity of items proposed, and the name of the manufacturer of the item.

C. Detail drawings consisting of equipment drawings, illustrations, schedules, instructions, diagrams and other information necessary to define the installation and enable the Owner to check conformity with the requirements of the Contract Drawings shall be submitted. Detail drawings shall as a minimum include:

1. Poles.
2. Crossarms and braces.
3. Transformers.
4. Conductors.
5. Insulators.
6. Surge arrestors.
7. Fused cutouts.
8. Hardware.
9. Line tension switches.

If departures from the Contract Drawings are deemed necessary by the Contractor, complete details of such departures shall be submitted with the detail drawings. Accepted departures shall be made at no additional cost to the Owner.

D. Detail drawings shall show how components are assembled, function together and how they will be installed on the project. Data and drawings for component parts of an item or system shall be

coordinated and submitted as a unit. Data and drawings shall be coordinated and included in a single submission. Detail drawings shall consist of the following:

1. Detail drawings showing physical arrangement, construction details, connections, finishes, materials used in fabrication, provisions for conduit or busway entrance, access requirements for installation and maintenance, physical size, electrical characteristics, foundation and support details, and equipment weight. Drawings shall be drawn to scale and/or dimensioned. Optional items shall be clearly identified as included or excluded.

2. Internal wiring diagrams of equipment showing wiring as actually provided for this project. External wiring connections shall be clearly identified.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Devices and equipment shall be visually inspected by the Contractor when received and prior to acceptance from conveyance. Stored items shall be protected from the environment in accordance with the manufacturer's published instructions. Damaged items shall be replaced. Oil-filled transformers and switches shall be stored in accordance with the manufacturer's requirements. Wood poles held in storage for more than 2 weeks shall be stored in accordance with ANSI Standards. Handling of wood poles shall be in accordance with ANSI Standards, except that pointed tools capable of producing indentations more than inch in depth shall not be used.

1.05 EXTRA MATERIALS

A. One additional spare fuse or fuse element for each furnished fuse or fuse element shall be delivered to the Owner when the electrical system is accepted. Two complete sets of all special tools required for maintenance shall be provided, complete with a suitable tool box. Special tools are those that only the manufacturer provides, for special purposes (to access compartments, or operate, adjust, or maintain special parts).

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

A. Products shall conform to the following requirements. Items of the same classification shall be identical, including equipment, assemblies, parts, and components.

2.02 STANDARD PRODUCT

A. Material and equipment shall be the standard product of a manufacturer regularly engaged in the manufacture of the product and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening.

2.03 NAMEPLATES

A. General

1. Each major component shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a nameplate securely attached to the equipment. Equipment containing liquid-dielectrics shall have the type of dielectric on the nameplate. Nameplates shall be made of non-corrosive metal. As a minimum, nameplates shall be provided for transformers, regulators, circuit breakers, capacitors, meters and switches.

2.04 CORROSION PROTECTION

A. Aluminum Materials

1. Aluminum shall not be used in contact with earth or concrete. Where aluminum conductors are connected to dissimilar metal, fittings conforming to UL Standards shall be used.

B. Ferrous Metal Materials

1. Hardware

a. Ferrous metal hardware shall be hot-dip galvanized in accordance with ASTM Standards.

2. Equipment

a. Equipment and component items shall be provided with corrosion-resistant finishes which shall withstand 120 hours of exposure to the salt spray test specified in ASTM Standards without loss of paint or release of adhesion of the paint primer coat to the metal surface in excess of 1.6mm (1/16 inch) from the test mark. Cut edges or otherwise damaged surfaces of hot-dip galvanized sheet steel or mill galvanized sheet steel shall be coated with a zinc rich paint conforming to the manufacturer's standard.

3. Finishing

a. Painting required for surfaces not otherwise specified and finish painting of items only primed at the factory shall be field painted.

2.05 CONDUCTORS, CONNECTORS, AND SPLICES

A. Aluminum-Composition Conductors

1. Aluminum-conductor-steel-reinforced, ACSR, shall comply with ASTM Standards.

B. Connectors and Splices

1. Connectors and splices shall be of copper alloys for copper conductors, aluminum alloys for aluminum-composition conductors, and a type designed to minimize galvanic corrosion for copper to aluminum-composition conductors.

2.06 MEDIUM-VOLTAGE LINES

A. Bare Medium-Voltage Lines

1. Bare medium-voltage line conductors shall be aluminum-conductor-steel-reinforced, ASCR, as indicated on the Drawings.

2.07 LOW-VOLTAGE LINES

A. Low-voltage line conductors shall be of the neutral-supported secondary and service drop type with cross-linked thermosetting polyethylene (XLP) insulation. Neutral-supported secondary and service drop conductors shall be insulated copper with bare hard-drawn-copper or copper-clad steel neutrals or insulated aluminum with bare 1350 alloy aluminum or ASCR neutrals, as indicated on the Drawings or to match existing.

2.08 POLES AND HARDWARE

A. Poles shall be of lengths and classes/strengths indicated.

B. Wood Poles

1. Wood poles shall comply with ANSI Standards and shall be pressure treated in accordance with AWPA, with pentachlorophenol preservatives conforming to AWPA P5. Wood poles shall have pole markings located approximately 3m (10 feet) from pole butts for poles 15.2m (50 feet) or less in length, and 4m (14 feet) from the pole butts for poles longer than 16.8m (55 feet) in length. Poles shall be machine trimmed by turning smooth full length, and shall be roofed, gained, and bored prior to pressure treatment. Where poles are not provided with factory-cut gains, metal gain plates shall be provided. Poles preserved with creosote or CCA are prohibited.

C. Pole Line Hardware

1. Zinc-coated hardware shall comply with ANSI C135.1, ANSI C135.2, ANSI C135.4, ANSI C135.14, ANSI C135.17, ANSI C135.22, and ANSI C135.33. Steel hardware shall comply with ASTM A 575 and ASTM A 576. Hardware shall be hot-dip galvanized in accordance with ASTM A 153. Pole-line hardware shall be hot-dip galvanized steel. Washers shall be installed under boltheads and nuts on wood surfaces and elsewhere as required. Washers used on through-bolts and double-arming bolts shall be approximately 57.2mm square (2 1/4 inches square) and 4.8mm (3/16 inches) thick. The diameter of holes in washers shall be the correct standard size for the bolt on which a washer is used. Washers for use under heads of carriage-bolts shall be of the proper size to fit over square shanks of bolts. Eye bolts, bolt eyes, eyenuts, strain-load plates, lag screws, fasteners, hooks, shims, and clevises shall be used wherever required to support and to protect poles, brackets, crossarms, guy wires, and insulators.

D. Guy Assemblies

1. Guy assemblies shall be zinc-coated steel in accordance with ASTM A 475. Guy assemblies, including insulators and attachments, shall provide a strength exceeding the required guy strength. Three-eye thimbles shall be provided on anchor rods to permit attachment of individual primary, secondary, and communication down guys. Anchors shall provide adequate strength to support all loads. Guy strand shall be 7 strand. Guy material shall be Class A zinc-coated-steel high-strength grade, with a minimum breaking strength no less than 10,000 pounds, except where two of more guys are used to provide the required strength. Guy rods shall be not less than 8 feet in length by 3/4 inch in diameter. See Drawings for other sizes used.

2.09 INSULATORS

A. Insulators shall comply with NEMA HV 2 for general requirements. Suspension insulators shall be used at corners, angles, dead-ends, other areas where pin insulators do not provide adequate strength, and as indicated. Mechanical strength of suspension insulators and hardware shall exceed the rated breaking strength of the attached conductors.

B. Medium-Voltage Line Insulators

1. Medium-voltage line insulators shall comply with ANSI C29.2, ANSI C29.5, and ANSI C29.6 as applicable. Ratings shall not be lower than the ANSI classes indicated in TABLE I. Pin insulators shall be used for crossarm construction. Pin insulators for use on voltages in excess of 6 kV phase-to-phase shall be radio-interference-freed.

Table I
Minimum ANSI Rating Of Medium-Voltage Insulators By Class

Voltage Level	Pin	Suspension
6 kV to 15 kV	55-2	Two 52-2

26 kV to 35 kV	56-4	Three 52-3 or 4

C. Low-Voltage Line Insulators

1. Low-voltage line insulators shall comply with ANSI C29.2 and ANSI C29.3 as applicable. Spool insulators for use on low-voltage lines shall be mounted on clevis attachments and shall be not smaller than Class 53-2. For No. 4/0 AWG and larger conductors, Class 53-4 shall be used. Suspension insulators on clevis attachments used at dead-ends shall not be smaller than Class 52-1.

D. Strain Insulators for Guy Wires

1. Strain insulators for use in insulated guy assemblies shall comply with ANSI C29.4 for porcelain or equivalent fiberglass, and shall have a mechanical strength exceeding the rated breaking strength of the attached guy wire. Insulators shall be not smaller Class 54-2 for lines of 6 kV to 15 kV (12,000 pounds tensile strength).

2.10 CROSSARM ASSEMBLIES

A. Crossarms

1. Crossarms shall comply with REA Bulletin 1728H-701 and shall be solid wood, distribution type, except cross-sectional area with pressure treatment conforming to AWPA C25, and a 6.4mm (1/4 inch), 45 degree chamfer on all top edges. Cross-sectional area minimum dimensions shall be 4-5/8 inches in height by 3-5/8 inches in depth in accordance with IEEE C2 for Grade C construction. Other sizes and types may be used. See Drawings. Crossarms shall be 2.4m (8 feet) in length, except that 3.1m (10 foot) crossarms shall be used for crossarm-mounted banked single-phase transformers or elsewhere as indicated. Crossarms shall be machined, chamfered, trimmed, and bored for stud and bolt holes before pressure treatment. Factory drilling shall be provided for pole and brace mounting, for four pin or four vertical line-post insulators, and for four suspension insulators, except where otherwise indicated or required. Drilling shall provide required climbing space and wire clearances. Crossarms shall be straight and free of twists to within 2.5mm per 304.8mm (1/10 inch per foot) of length. Bend of twist shall be in one direction only.

B. Crossarm Gains

1. Crossarm gains shall comply with ANSI C135.33.

2.11 FUSES AND SWITCHES, MEDIUM-VOLTAGE

A. Fuse Cutouts

1. Medium-voltage fuses and cutouts shall comply with NEMA SG 2 and shall be of the loadbreak, open type construction, rated 7.8 kV and of the ratings and types indicated. Open-link cut-outs are not acceptable. Fuses shall be either indicating or dropout type. Fuse ratings shall be as indicated. Fuse cutouts shall be equipped with mounting brackets suitable for the indicated installations.

B. Nonfused Switches

1. Nonfused switches shall be single-pole, manual devices with a continuous current rating of 600 amperes rms, a momentary asymmetrical current rating of 40 kA rms, and shall be rated for 15 kV. Units shall be crossarm mount type or line tension as shown in the Drawings.

2. *Provide 200 ampere cutouts fused at 150 amperes, S&C Type XS or equal. Provide one portable Loadbreak tool for the project."*[ADD#5]

2.12 TRANSFORMERS

A. Refer to specification Section 16270 and the Drawings.

2.13 SURGE ARRESTORS

A. Surge arrestors shall comply with NEMA LA 1 and IEEE C62.1, IEEE C62.2, and IEEE C62.11, and shall be provided for protection of aerial-to-underground transitions, transformers and other indicated equipment. Arrestors shall be heavy-duty distribution class, rated ~~3 kV~~ *9 kV*[ADD#5]. Arrestors shall be equipped with mounting brackets suitable for the indicated installations. Arrestors shall be of the combination valve-metal-oxide varistor type suitable for outdoor installations.

2.14 GROUNDING AND BONDING

A. Driven Ground Rods

1. Ground rods shall be of copper-clad steel not less than 19.1mm (3/4 inch) in diameter by 3.1 meter (10 feet) in length of the sectional type driven full length into the earth.

B. Grounding Conductors

1. Grounding conductors shall be bare copper, except where installed in conduit with associated phase conductors. Insulated conductors shall be of the same material as the phase conductors and green color-coded, except that conductors shall be rated no more than 600 volts. Bare conductors shall be soft-drawn unless otherwise indicated. Aluminum is not acceptable. Minimum size #6.

PART 3 - EXECUTION

3.01 GENERAL INSTALLATION REQUIREMENTS

A. Equipment and devices shall be installed and energized in accordance with the manufacturer's published instructions.

B. Conformance to Codes

1. The installation shall comply with the requirements and recommendations of IEEE C2 for heavy loading district, Grade C construction. No reduction in clearance shall be made. The installation shall also comply with the applicable parts of NFPA 70.

C. Verification of Dimensions

1. The Contractor shall become familiar with details of the work, shall verify dimensions in the field, and shall notify the Owner of any discrepancy before performing any work.

D. Tree Trimming

1. Where lines pass through trees, trees shall be trimmed at least 4.5 m (15 feet) clear on both sides horizontally and below for medium-voltage lines, and 1.5 m (5 feet) clear on both sides horizontally and below for other lines, and no branch shall overhang horizontal clearances.

3.02 POLE INSTALLATION

A. Joint-use electric/roadway-lighting poles for overhead electric and communication lines shall be wood poles utilizing crossarm construction. Cluster-mounted banked single-phase transformer installations shall be provided. Crossarm construction shall be provided for support of other equipment, except where direct-pole mounting is indicated. Provision for communication services is required on pole-line construction, except where specifically noted otherwise. A vertical pole space shall be reserved at all locations.

B. Wood Pole Setting: Wood poles shall be set straight and firm. In normal firm ground, minimum pole-setting depths shall be as listed in Table II. In rocky or swampy ground, pole-setting depths shall be decreased or increased respectively in accordance with the local utility's published standards and as approved. Poles in straight runs shall be in a straight line. Curved poles shall be placed with curvatures in the direction of the pole line. Poles shall be set to maintain as even a grade as practicable. When the average ground run is level, consecutive poles shall not vary more than 1.5 m (5 feet) in height. When the ground is uneven, poles differing in length shall be kept to a minimum by locating poles to avoid the highest and lowest ground points. If it becomes necessary to shorten a pole, a piece shall be sawed off the top end and roofed. If any pole is shortened after treatment, the shortened end of the pole shall be given an application of hot preservative. Where poles are set on hilly terrain, along edges of cuts or embankments, or where soil may be washed out, special precautions shall be taken to ensure durable pole foundations, and the setting depth shall be measured from the lower side of the pole. Holes shall be dug large enough to permit proper use of tampers to the full depth of a hole. Earth shall be placed into the hole in 300 mm (6 inch) maximum layers, then thoroughly tamped before the next layer is placed. Surplus earth shall be placed around each pole in a conical shape and packed tightly to drain water away from poles.

Table II Minimum Pole Setting Depth (Meters)		
Length Overall Meters	**Straight Lines**	**Curves, Corners, and Points of Extra Strain**
7.6	1.7	1.7
9.2	1.7	1.7
10.7	1.8	1.8
12.2	1.8	1.8
13.7	2.0	2.1
15.2	2.1	2.3
16.7	2.3	2.5
18.3	2.5	2.6
19.8	2.6	2.6
21.3	2.8	2.9
22.9	2.9	3.0
24.4	3.0	3.2
25.9	3.2	3.3
27.4	3.3	3.5
28.9	3.5	3.7
30.5	3.7	3.8

Table II Minimum Pole-Setting Depth (Feet)		
Length Overall Feet	**Straight Lines**	**Curves, Corners, and Points of Extra Strain**
20	5.0	5.0
25	5.5	5.5
30	5.5	5.5
35	6.0	6.0
40	6.5	6.5
45	6.5	7.0
50	7.0	7.5
55	7.5	8.0
60	8.0	8.5
65	8.5	9.0
70	9.0	9.5
75	9.5	10.0
80	10.0	10.5
85	10.5	11.0
90	11.0	11.5
95	11.5	12.0
100	12.5	12.5

3.03 CROSSARM MOUNTING

A. Crossarms shall be bolted to poles with 15.9 m (5/8 inch) through-bolts with square washers at each end. Bolts shall extend not less than 3 mm (1/8 inch) nor more than 50 mm (2 inches) beyond nuts. On single crossarm construction, the bolt head shall be installed on the crossarm side of the pole. Metal or wood crossarm braces shall be provided on crossarms. Flat braces may be provided for 2.4 m (8 foot) crossarms and shall be 6.4 by 31.8 mm (1/4 by 1-1/4 inches), not less than 700 mm (28 inches) in length. Flat braces shall be bolted to arms with 9.5 mm (3/8 inch) carriage bolts with round or square washers between boltheads and crossarms, and secured to poles with 50.8 by 101.6 mm (2 by 4 inch) lag screws after crossarms are leveled and aligned. Angle braces are required for 3.1 m (10 foot) crossarms and shall be 1.5 m (60 inch) span by 457.2 mm (18 inch) drop formed in one piece from 38.1 by 38.1 by 4.8 mm (1-1/2 by 1-1/2 by 3/16 inch) angle. Angle braces shall be bolted to crossarms with 50.8 mm (2 inch) bolts with round or square washers between boltheads and crossarms, and secured to poles with 15.9 mm (5/8 inch) through-bolts. Double crossarms shall be securely held in position by means of 15.9 mm (5/8 inch) double-arming bolts. Each double-arming bolt shall be equipped with four nuts and four square washers.

B. Line arms and buck arms shall be set at right angles to lines for straight runs and for angles 45 degrees and greater; and line arms shall bisect angles of turns of less than 45 degrees. Dead-

end assemblies shall be used for turns where shown. Buckarms shall be installed, as shown, at corners and junction poles. Double crossarms shall be provided at ends of joint use or conflict sections, at dead-ends, and at angles and corners to provide adequate vertical and longitudinal strength. Double crossarms shall be provided at each line-crossing structure and where lines not attached to the same pole cross each other.

C. Equipment arms shall be set parallel or a right angles to lines as required to provide climbing space. Equipment arms shall be located below line construction to provide necessary wire and equipment clearances.

3.04 GUY INSTALLATION

A. Guys shall be provided where shown, with loads and strengths as indicated, and wherever conductor tensions are not balanced, such as at angles, corners, and dead-ends. Where a single guy will not provide the required strength, two or more guys shall be provided. Approved guy grips shall be provided at each guy terminal. Guy-strain insulators shall be provided in each guy for wood poles. Rock anchors shall be installed in rock at right angles to guys, elsewhere anchors shall be of an expanding type, except that power installed screw anchors of equivalent holding power are acceptable. A half-round yellow polyvinyl, fiberglass, or other suitable plastic guy marker, not less than 2.4 m (8 feet) in length, shall be provided at the anchor end of each guy shown, securely clamped to the guy or anchor at the bottom and top of the marker. Holding capacities for down guys shall be based on a lead angle of 45 degrees.

3.05 CONDUCTOR INSTALLATION

A. Line Conductors:

1. Unless otherwise indicated, conductors shall be installed in accordance with manufacturer's approved tables of sags and tensions. Proper care shall be taken in handling and stringing conductors to avoid abrasions, sharp bends, cuts, kinks, or any possibility of damage to insulation or conductors. Conductors shall be paid out with the free end of conductors fixed and cable reels portable, except where terrain or obstructions make this method unfeasible. Bend radius for any insulated conductor shall not be less than the applicable NEMA specification recommendation. Conductors shall not be drawn over rough or rocky ground, nor around sharp bends. When installed by machine power, conductors shall be drawn from a mounted reel through stringing sheaves in straight lines clear of obstructions. Initial sag and tension shall be checked by the Contractor, in accordance with the manufacturer's approved sag and tension charts, within an elapsed time after installation as recommended by the manufacturer.

B. Connectors and Splices:

1. Connectors and splices shall be mechanically and electrically secure under tension and shall be of the nonbolted compression type. The tensile strength of any splice shall be not less than the rated breaking strength of the conductor. Splice materials, sleeves, fittings, and connectors shall be non-corrosive and shall not adversely affect conductors. Aluminum-composition conductors shall be wire brushed and an oxide inhibitor applied before making a compression connection. Connectors which are factory-filled with an inhibitor are acceptable. Inhibitors and compression tools shall be of types recommended by the connector manufacturer. Primary line apparatus taps shall be by means of hot line clamps attached to compression type bail clamps (stirrups). Low-voltage connectors for copper conductors shall be of the solderless pressure type. Non-insulated connectors shall be smoothly taped to provide a waterproof insulation equivalent to the original insulation, when installed on insulated conductors. On overhead connections of aluminum and copper, the aluminum shall be installed above the copper.

C. Conductor-To-Insulator Attachments

1. Conductors shall be attached to insulators by means of clamps, shoes or tie wires, in accordance with type of insulator. For insulators requiring conductor tie-wire attachments, tie-wire sizes shall be as indicated in Table III.

Table III
Tie-Wire Requirements

Conductor Copper (AWG)	**Tie Wire Soft-Drawn Copper (AWG)**
6	8
4 and 2	6
1 through 3/0	4
4/0 and larger	2
ACSR (AWG)	**AAAC or AAC (AWG)**
Any Size	6 or 4

D. Armor Rods:

1. Armor rods shall be provided for ACSR conductors. Armor rods shall be installed at supports, except armor rods will not be required at primary dead-end assemblies if aluminum or aluminum-lined zinc-coated steel clamps are used. Lengths and methods of fastening armor rods shall be in accordance with the manufacturer's recommendations. For span lengths of less than 61 m, (200 feet,) flat aluminum armor rods may be used. Flat armor rods shall be not less than 1.3 by 7.6 mm (0.05 by 0.30 inches). For span lengths of 61 m (200 feet) or more, preformed round armor rods shall be used. **In lieu of armor rods, neoprene coated tie wires designed to protect the conductor from abrasion at connections may be used at Contractor's discretion. Such ties shall also provide a conductor pad.**

E. Low-Voltage Insulated Cables

1. Low-voltage cables shall be supported on clevis fittings using spool insulators. Dead-end clevis fittings and suspension insulators shall be provided where required for adequate strength. Dead-end construction shall provide a strength exceeding the rated breaking strength of the neutral messenger. Clevis attachments shall be provided with not less than 15.9 mm (5/8 inch) through-bolts.

3.06 CONNECTIONS TO UTILITY LINES

A. The Contractor shall coordinate the work with Kentucky Utilities, and shall provide for final connections to the utility electric lines.

3.07 CONNECTIONS TO BUILDINGS

A. Aerial Services:

1. Connections to buildings shall be made at approximately the point indicated and shall be connected to the service entrance conductors. Supports at buildings shall be adequate to withstand required pulls; supports shall not be rated less than 4450 N (1000 pounds). Drip loops shall be formed on conductors at entrances to buildings, cabinets, or conduits.

3.08 GROUNDING

A. Noncurrent-carrying metal parts of equipment and conductor assemblies, such as luminaires, medium-voltage cable terminations and messengers, operating mechanisms of pole top switches, panel enclosures, transformers, and other non-current-carrying metal items shall be grounded. Additional grounding of equipment, neutral, and surge arrester grounding systems shall be installed at poles where indicated.

B. Grounding electrodes shall be installed as follows:

1. Driven rod electrodes - unless otherwise indicated, ground rods shall be located approximately 900 mm (3 feet) out from base of the pole and shall be driven into the earth until the tops of the rods are approximately 300 mm (1 foot) below finished grade. Multiple rods shall be evenly spaced at least 3 m (10 feet) apart and connected together 600 mm (2 feet) below grade with a minimum No. 6 bare copper conductor.

2. Pole butt electrodes - Pole butt electrodes shall be installed where indicated, except that this method shall not be the sole grounding electrode at transformer locations. The pole butt electrode shall consist of a coil of at least 4 m (12 feet) of minimum No. 6 bare copper conductor stapled to the butt of the pole.

3. Plate electrodes - Plate electrodes shall be installed in accordance with the manufacturer's instructions and IEEE C2 and NFPA 70.

4. Ground Resistance - The maximum resistance of a driven ground rod shall not exceed 25 ohms under normally dry conditions. Whenever the required ground resistance is not met, provide additional electrodes interconnected with grounding conductors, to achieve the specified ground resistance. The additional electrodes will be up to three, 3 m (10 feet) rods spaced a minimum of 3 m (10 feet) apart. If the resultant resistance exceeds 25 ohms measured not less than 48 hours after rainfall, the Owner shall be notified. Connections below grade shall be exothermically welded. Connections above grade shall be exothermically welded or shall use UL 467 approved connectors.

C. Grounding and Bonding Connections:

1. Connections above grade shall be made by the exothermically-welding process or with bolted solderless connectors in compliance with UL 467, and those below grade shall be made by the exothermically welding process. Where grounding conductors are connected to aluminum-composition conductors, specially treated or lined copper-to-aluminum connectors suitable for this purpose shall be used.

D. Grounding Electrode Conductors:

1. On multi-grounded circuits, as defined in IEEE C2, provide a single continuous vertical grounding electrode conductor. Neutrals, surge arresters, and equipment grounding conductors shall be bonded to this conductor. For single grounded or ungrounded systems, provide a grounding conductor for the surge arrester and equipment grounding conductors and a separate grounding conductor for the secondary neutrals. Grounding electrode conductors shall be sized as shown. Secondary system neutral conductors shall be connected directly to the transformer neutral bushings, then connected with a neutral bonding jumper between the transformer neutral bushing and the vertical grounding electrode conductor, as shown. Grounding electrode conductors shall be stapled to wood poles at intervals not exceeding 600 mm (2 feet). Bends greater than 45 degrees in grounding electrode conductor are not permitted. Protective molding shall be installed over pole grounding conductors.

3.09 FIELD TESTING

A. General

1. Field testing shall be performed in the presence of the Owner's representative. The Contractor shall notify the Owner two (2) days prior to conducting tests. The Contractor shall furnish materials, labor, and equipment necessary to conduct field tests. The Contractor shall perform tests and inspections recommended by the manufacturer. The Contractor shall maintain a written record of tests which includes date, test performed, personnel involved, devices tested, serial number and name of test equipment, and test results. Field reports will be signed and dated by the Contractor.

B. Safety

1. The Contractor shall provide and use safety devices such as rubber gloves, protective barriers, and danger signs to protect and warn personnel in the test vicinity. The Contractor shall replace any devices or equipment, which are damaged due to improper test procedures or handling.

C. Ground-Resistance Tests

1. The resistance of each grounding electrode system shall be measured using the fall-of-potential method defined in IEEE Std. 81. Ground resistance measurements shall be made before the electrical distribution system is energized and shall be made in normally dry conditions not less than 48 hours after the last rainfall. Resistance measurements of separate grounding electrode systems shall be made before the systems are bonded together below grade. The combined resistance of separate systems may be used to meet the required resistance, but the specified number of electrodes shall be provided.

D. Sag and Tension Test

1. The Owner shall be given prior notice of the time schedule for stringing conductors or cables serving overhead medium-voltage circuits and reserves the right to witness the procedures used for ascertaining that initial stringing sags and tensions are in compliance with requirements for the applicable loading district and cable weight.

E. Low-Voltage Cable Test (Only Required When New Cable Installed.)

1. For service laterals from overhead lines, the low-voltage cable, complete with splices, shall be tested for insulation resistance after the cables are installed, in their final configuration, ready for connection to the equipment, and prior to energization. The test voltage shall be 500 volts dc, applied for one minute between each conductor and ground and between all possible combinations of conductors in the same cable. The minimum value of insulation shall be:

   R in megohms = (rated voltage in kV +1) x 304,800/ (length of cable in meters)

   R in megohms = (rated voltage in kV +1) x 1000/ (length of cable in feet)

2. Each cable failing this test shall be repaired or replaced. The repaired cable shall then be retested until failures have been eliminated.

F. Liquid-Filled Transformer Tests (Required After Temporary Hook-up and After Final Connection to New Line.)

1. The following field tests shall be performed on liquid-filled transformers. Pass-fail criteria shall be in accordance with the transformer manufacturer's specifications.

   a. Correct phase sequence.

G. Pre-Energization Services

1. The following services shall be performed on the equipment listed below. These services shall be performed subsequent to testing but prior to the initial energization. The equipment shall be inspected to ensure that installation is in compliance with the recommendations of the manufacturer and as shown on the detail drawings. Terminations of conductors at major equipment shall be inspected to ensure the adequacy of connections. Bare and insulated conductors between such terminations shall be inspected to detect possible damage during installation. If factory tests were not performed on completed assemblies, tests shall be performed after the installation of completed assemblies. Components shall be inspected for damage caused during installation or shipment and to ensure that packaging materials have been removed. Components capable of being both manually and electrically operated shall be operated manually prior to the first electrical operation. Components capable of being calibrated, adjusted, and tested shall be calibrated, adjusted, and tested in accordance with the instructions of the equipment manufacturer. Items for which such services shall be provided, but are not limited to, are the following:

   Switches.

   Cutouts.

H. Operating Tests

1. After the installation is completed, and at such time as the Owner may direct, the Contractor shall conduct operating tests for acceptance. The equipment shall be demonstrated to operate in accordance with the specified requirements.

3.10 ACCEPTANCE

A. Final acceptance of the project will not be given until the Contractor has successfully completed all tests and after all defects in installation, material or operation have been corrected.

END OF SECTION

SECTION 16440 - MOTOR CONTROL

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. Contractor shall furnish and install motor control equipment as specified herein and as shown on the Drawings.

1.02 SUBMITTALS

A. Motor control equipment shall be new and the equipment of one manufacturer. Each component is specified by a particular trade name; however, this does not relieve the Contractor of the responsibility of submitting descriptive literature and Shop Drawings for review of all components. Motor control shall be the same brand as power distribution equipment on projects with both.

B. Shop drawings, including layout drawings, complete schematic and composite wiring diagrams, control circuit wiring diagrams and descriptive literature shall be submitted to the Engineer for review. **Service manuals shall be submitted on all equipment and shall be bound in 3-ring looseleaf binders.** The manuals shall also include information on accessories such as timers, etc., built in the control center.

1.03 SERVICE OF MANUFACTURER'S REPRESENTATIVE

A. The Contractor shall provide the services of a qualified manufacturer's technical representative who shall adequately supervise the installation and testing of all equipment furnished under this Contract and instruct the Contractor's personnel and the Owner's operating personnel in its maintenance and operation as outlined elsewhere in Division 1. The services of the manufacturer's representative shall be provided for a period of not less than as follows:

1. One trip of one (1) working day during installation of the equipment for each motor control center.

2. One trip of one (1) working day after acceptance of the equipment.

3. One trip of one (1) working day during the warranty period.

B. Any additional time required to achieve successful installation and operation shall be at the expense of the Contractor. The manufacturer's representative shall sign in and out at the office of the Engineer's Field Representative on each day he is at the project.

1.04 TRAINING

A. The Contractor shall provide training for Owner personnel. Training shall be conducted by the manufacturer's factory trained specialists who shall instruct Owner personnel in operation and maintenance of all equipment provided under this Section.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Control Equipment

1. "Square D", "Cutler Hammer", "Allen Bradley", or equal.

B. Timers

1. "Paragon", "Tork", "Intermatic", or equal.

2.02 MOTOR CONTROL CENTERS (MCC)

A. General

1. Quality of built-in transformers, starters, lighting panelboards, timers, etc. shall be as written elsewhere in this Division unless otherwise noted.

2. Motor Control Center(s) shall consist of one or more enclosed vertical sections joined together to form a rigid, free standing assembly. The construction of the Motor Control Center shall meet the requirements set forth by Underwriters' Laboratories publication UL-845, NEMA publication number ICS-2-322, the National Electrical Code, and color coded.

3. The structure shall be UL listed and labeled as service equipment if applicable. All sections shall bear UL labels.

4. Enclosures shall be NEMA 1 unless otherwise indicated, and each control center suitable for connection to an available fault current of 65,000 RMS symmetrical amperes unless otherwise indicated on the Drawings.

B. Construction

1. Vertical Sections

a. Vertical sections shall support the horizontal and vertical buses, combination starter units, covers and doors, and shall be designed to allow for easy rearrangement of units by the purchaser. Vertical sections shall have structural supporting members formed of a minimum of 13 gauge hot-rolled steel. All finished surfaces shall be blemish-free. Where needed, reinforcement structural parts shall be of 10-gauge steel to provide a strong rigid assembly. Each section shall be 90 inches high and shall have 7 gauge steel, 3 inch high removable lifting angle and two 1 1/2 inch high base channels. Complete control center line-ups shall be divided into shipping splits no wider than approximately 60 inches. The lifting angle shall be provided on the top of each shipping split and shall extend the entire width of the shipping split. Lifting angles shall be designed to support the entire weight of the MCC section. Base channels shall be provided with holes to permit bolting the Motor Control Center(s) to the floor. The entire assembly shall be constructed and packaged to withstand all stresses induced in transit and during installation.

b. Motor Control Centers shall be designed so that matching vertical sections of the same current rating and manufacture can be added later at either end of the line-up without use of transition sections and without difficulty or undue expense. Removable end closing plates shall be provided to close off openings on the end of the Motor Control Center line-up. A removable top plate shall be provided on each vertical section and shall be of one-piece construction for added convenience in

cutting conduit holes. The design shall allow use of the standard conduit entrance area without significant sag or deformation of the top plate.

c. Vertical sections shall be designed to accommodate plug-on units in front-of-board or back-to-back construction as shown on Contract Drawings. Vertical sections housing plug-on units shall be 20 inches wide and shall be 20 inches deep. Wider sections will be permitted only for bolted connection type units not fitting the 20-inch wide sections. Unit mounting area shall be divided into 1/2 space factor divisions, each approximately 6 inches. NEMA Size 1 and 2 combination starter units shall use only 1 space factor, or 12 inches, of unit mounting space. Vertical sections shall allow for 7 space factors of unit mounting space. Removable blank plates shall cover all unused unit-mounting spaces. Blank plates shall be flanged on all 4 sides and shall be mounted with captive screws. Blank space shall be equipped for future use.

d. Vertical sections shall be provided with both horizontal and vertical wireways. Sufficient clearances shall be provided in the horizontal wireway so that no restriction is encountered in running wires from the vertical to horizontal wireway. Wireways shall be in accordance with the wireway sections contained in this document.

2. Horizontal Wireways

a. Horizontal wireways shall be provided in the top and bottom of each vertical section as indicated in the Contract Drawings and shall be arranged to provide full-length continuity throughout the entire assembly. The top horizontal wireway shall have a cross sectional area of not less than 20 square inches with openings between sections of not less than 11/2 square inches. The bottom horizontal wireway shall extend through the length and depth of the vertical sections and shall also be provided with openings of not less than 11/2 square inches to allow for full length continuity throughout the entire assembly. The bottom horizontal wireway height shall be not less than 9 1/4 inches. Covers for all wireways shall be equipped with captive type screws to prevent loss of hardware during installation. All wireways shall be isolated from the bus bars.

3. Vertical Wireways

a. A vertical wire trough shall be located on the right -hand side of each vertical section and shall extend from the top horizontal wireway to the bottom of the available unit mounting space. Each vertical wire trough shall have a cross sectional area of not less than 19 square inches and shall be isolated from the bus bars to guard against accidental contact. A separately hinged door having captive type screws shall cover the vertical wire trough to provide easy access to control wiring without disturbing control units.

b. Reusable wire ties shall be furnished in each vertical wire trough for the purpose of grouping and securely holding wires in place for a neat and orderly installation.

4. Busbars

a. A continuous main three-conductor horizontal bus shall be provided over the full length of the control center. A fully rated horizontal neutral bus (1200 ampere maximum) shall also be supplied over the full length of the Motor Control Center. When necessary, the bus shall be split to allow for ease in moving and handling. Splice bars will be supplied to join the bus wherever a split has been made. All splice connections shall be made with at least two bolts and shall employ the use of Belleville washers in the connection. Horizontal bus bars shall be mounted edgewise and supported by insulated bus supports.

b. For distribution of power from the main horizontal bus to each unit compartment, a three-phase vertical bus shall be provided. The vertical bus shall be firmly bolted to the horizontal bus for permanent contact.

c. The main horizontal and vertical buses shall be made of copper and the entire length shall be electrolytically tin plated to provide maximum protection to the bus bars from normal or adverse atmospheric conditions.

d. Bus supports shall be formed of high strength glass reinforced alkyd material. Bus supports shall have generous surface clearances in the vertical plane to shed dust and maintain dielectric integrity. Bus supports and insulators shall be red to indicate proximity of energized bus parts.

e. Horizontal and vertical buses shall have continuous current ratings adequate to handle all loads as shown on the one line diagram in the Contract Drawings. Continuous current ratings shall be in accordance with temperature rise specifications established by UL, ANSI, and NEMA standards.

f. A copper ground lug shall be provided in each incoming line vertical section capable of accepting a #8 to 250 MCM cable. A horizontal copper grounding bus shall be provided in each section of the Motor Control Center. Horizontal grounding bus shall run continuously throughout the control center except where splits are necessary for ease of shipment and handling in which case splice bars shall be provided. Grounding bus shall be tin plated copper and have a cross sectional area equal to 28% of the main horizontal bus cross sectional area. Horizontal ground bus shall be located at the bottom of the Motor Control Center.

5. Bus Barriers

a. Insulated horizontal and vertical bus barriers shall be furnished to reduce the hazard of accidental contact with the bus. Barriers shall have a red color to indicate proximity of energized buses. Vertical bus barriers shall have interlocking front and back pieces to give added protection on all sides and shall segregate the phases to reduce the possibility of accidental "flash over". Small, separate openings in the vertical bus barriers shall permit unit plug-on contacts to pass through and engage the vertical bus bars. Bottom bus covers shall be provided below the vertical bus to protect the ends of the bus from accidental contact with fish tapes or other items entering from the bottom of the enclosure.

b. Isolation of unused stab openings shall be accomplished by use of a manual shutter to close off the stab opening. These shutters shall be attached to the structure so that when they are removed (to allow a stab connection) they are retained in the structure and are readily accessible for use should a plug-in unit be removed from the motor control center.

6. Main Incoming Lug Compartment

a. A front accessible main lug compartment shall be provided with suitable main lugs to accommodate the number of cables per phase as indicated on the Contract Drawings. The compartment shall be located in the top most or bottom most unit space of the section to accommodate the user's cables entering the Motor Control Center as indicated on the Contract Drawings. The main incoming lug compartment shall be covered by a hinged door for maintenance access. This door shall be held closed with captive type screws to discourage unauthorized access. (A unit door padlock attachment shall also be provided to lock the door in the closed position with one 5/16 inch diameter shackle padlock. This attachment shall also accept a meter type seal.)

7. Units

a. Combination starter units shall consist of Size 1 minimum full voltage magnetic starters, autotransformer reduced voltage starters, molded case magnetic-only circuit breakers, and auxiliary control devices, as required and/or shown on the one-line and elementary diagrams. Pilot light assemblies (push-to-test) shall be 30 mm LED. All auxiliary equipment, except that which is specified for mounting on the door, shall be mounted within the compartment. All units shall be provided with unit doors, unit support pans, unit saddles and unit disconnect operators as outlined in this Specification. Each unit compartment shall be enclosed and isolated from adjacent units, buses and wireways except for openings for conductor entrance into units. Units shall be designed and constructed so that any fault will be localized within the compartment. All units shall be UL listed for minimum of 65,000 amperes RMS symmetrical fault withstand ability unless otherwise indicated on the Drawings.

b. Plug-on combination starter units of the same NEMA size and branch feeder units of the same trip size shall be readily interchangeable with each other. It shall be possible to withdraw each plug-on unit to a de-energized position with the unit still being supported by the structure. It shall be possible to lock the unit in this position with one padlock.

c. Full voltage non-reversing combination starter units shall have the following minimum space factor requirements, shall be provided with plug-on connections and shall be provided with ample space for customer wiring room:

	Circuit Breaker Space Factor
Size 1	1
Size 2	1
Size 3	1 1/2
Size 4	2

8. Unit Plug-On

a. For convenient unit connection to bus bars, unit plug-on contacts shall be provided on the following units:

1) For circuit breaker type units; full voltage starters, size 4 and smaller; auto-transformer reduced voltage starters, size 4 and smaller; part winding reduced voltage starters, size 4PW and smaller; branch circuit units, 225 ampere and smaller.

b. The plug-on connection for each phase shall be of a high quality two- point connection and shall be designed to tighten around the vertical bus bar during a heavy current surge. For trouble-free connections, the plug-on fingers shall be silver plated and coated with a compound to assure a low resistance connection. Contact fingers shall be of a floating and self-aligning design to allow solid seating onto the vertical bus bars.

c. Starters NEMA size 4 and larger shall bolt directly to the vertical bus bars, circuit breakers rated higher than 225 amps shall also bolt directly to the bus bars.

9. Unit Doors

a. Each unit shall have a door securely mounted with rugged concealed-type hinges which allow the door to swing open a minimum of 112° for unit maintenance and withdrawal. Doors shall be fastened to the structure so that they remain in place when a unit is withdrawn and may be closed to cover the unit space when the unit has been temporarily removed. Doors shall be held closed with captive type screws which engage self-aligning cage nuts. These screws shall provide at least two

threads of engagement to hold doors closed under fault conditions. Each unit door shall be interlocked with its disconnect mechanism to prevent the door from opening when the unit is energized. A defeater mechanism shall be provided for defeating this interlock by authorized personnel. Removable door panels held with captive type screws shall be provided on starter unit doors for mounting push buttons, selector switches or pilot lights. Blank door panels capable of accepting future pilot devices shall be furnished when pilot devices are not originally specified for starter units. Each starter unit door shall house an external low-profile overload reset button for resetting the overload relay in the event of tripping.

10. Unit Support Pan

    a. Each plug-on unit shall be supported and guided by a tilt and lift-out removable pan so that unit rearrangement can be easily accomplished. For easy unit installation and rearrangement, transfer of this unit support pan from one location to another shall be accomplished with ease after the control unit and door have been removed.

11. Unit Saddles

    a. Each plug-on unit shall have a saddle of 14 gauge hot rolled steel designed and constructed to physically isolate the unit from the bus compartment and adjacent units. Saddlers shall be equipped with captive, self-aligning mounting screws which shall hold the unit securely in place during shipment. Flanged edges shall be provided on each saddle to facilitate unit removal.

12. Disconnect Operators

    a. An external operator handle shall be supplied for each switch or breaker. This mechanism shall be engaged with the switch or breaker at all times regardless of unit door position to prevent false circuit indication. The operator handle shall be color coded to display red in the "ON" position and black in the "OFF" position. The operator handle shall have a conventional up-down motion and shall be designed so that the down position will indicate the unit is "OFF". For added safety it shall be possible to lock this handle in the "OFF" position with up to three padlocks. The operator handle shall be interlocked with the unit door to prevent switching the unit to "ON" while the unit door is open. A defeater mechanism shall be provided for the purpose of defeating this interlock by a deliberate act of an electrician should he desire to observe the operation of the operator handle assembly or the unit components. Operators shall not be higher than 6'-6" above finished floor elevation, as installed.

13. Wiring

    a. The motor control center wiring shall be NEMA Class II, Type B.

    b. All wiring to the terminal strips from outside the MCC shall be made with spade type terminals of the proper size and rating for the wire used. Pull apart terminal blocks shall be provided in unit spaces of motor starters that contain field wiring energized from a remote source to comply with NEC Article 430-74.

    c. All control wiring shall be No. 14 AWG (minimum) labeled at each end in accordance with the wiring numbers shown on the accepted shop drawings. Power wiring shall be sized to suit the maximum horsepower rating of unit; No. 12 AWG (minimum). Wiring shall be type MTW rated for 105□C. Wire color coding shall be red for control and black for power. Wire numbers shall not be repeated in a motor control center.

14. Finish

a. The finish shall be manufacturer's standard gray enamel applied over a rust inhibiting phosphate primer.

15. Optional Modifications and Accessories

a. Additional modifications and accessories shall be as listed and specified on the Contract Drawings.

16. Identification

a. A control center identification nameplate describing section catalog numbers and characteristics shall be fastened on the vertical wire trough door of every section. Each control center unit shall have its own identification nameplate fastened to the unit saddle. These nameplates shall have suitable references to factory records for efficient communication with supplier. Each control center unit shall also have an engraved Bakelite nameplate fastened to the outside of each unit door inscribed as written on the Contract Drawings for ease in identification and for making changes when regrouping units. An overall structure nameplate is also required.

17. Metering

a. All voltmeters, ammeters, wattmeters, current transformers, potential transformers and phase selector switches shall be furnished as shown on the Contract Drawings. Meter accuracy shall be $\pm$ 1 percent. Solid state metering shall be as specified this section.

18. Surge Protective Devices

a. Specification Section 16280 – Surge Protective Devices for motor control center SPD requirements.

C. Starters and Overcurrent Protective Devices

1. Magnetic Starters

a. Magnetic starters shall be furnished in all combination starter units unless otherwise indicated on Contract Drawings. Starter Sizes 1 through 4 shall employ the use of a bell-crank lever design to transform vertical action of the armature into horizontal action of the contact carriers and thus minimize contact bounce and produce extra long contact life. Thermal overload relays on starters shall be ambient temperature compensated bimetallic type with selector for either auto or manual reset. Overload heater units shall be provided in each starter unit. Overload relay heater schedules shall be provided on each starter unit.

2. Circuit Breakers

a. Type FA, KA, LA, MA and PA molded case circuit breakers shall be furnished in all starter and branch feeder units using circuit breakers as a disconnect means. All circuit breakers will have a push-to-trip test feature for testing and exercising the circuit breaker trip mechanism.

3. Starters shall conform to requirements listed under individually mounted Motor Control Devices, hereinafter.

D. Lighting Panelboards

1. Lighting panelboards shall be as specified in other section of this Division. Lighting panelboard unit doors shall be held closed with captive latches that may easily be operated without the use of tools, i.e., wing nuts, handle, etc.

E. Transformers

1. 480 volt primary, 120/240 volt or 120/208 volt secondary transformers shall be as specified in other sections of this Division.

2.03 WEATHERPROOF WALK-IN MCC HOUSING

A. A weatherproof walk-in housing is required on this project for MCC-WWS. The housing/MCC combination shall be factory assembled and construction arranged to facilitate Contractor installation. The housing shall be approximately 10 feet wide, length as required, and at least 8 feet high inside, for a non-hazardous environment. The base shall be constructed of welded steel I-beams, channels, and angle supports, sized and reinforced to accommodate loading requirements. The base shall be primed with zinc chromate, followed by a layer of bituminous undercoating. The base exterior shall be finished with epoxy coating. The floor shall be steel plate welded to the base framework. Floor material shall be tread plate finished with skid resistant epoxy. Wall panel material shall be galvanized, formed in an interlocking design which is self-framing and capable of withstanding wind loads of 90 mph, of 12 gauge thickness. Roof panels shall be galvanized, formed of 12 gauge steel in a standing rib design eliminating the possibility of water entry. The roof shall be sloped for water runoff and capable of withstanding snow loads of 20 psf. The entire housing shall be painted with 3-5 mils of epoxy paint. Color shall be off-white outside and gray to match the MCC inside. The floor shall have 1 inch duct board insulation, the walls 3 inch bat insulation, and the ceiling 3 2 inch bat insulation.

B. Fluorescent lighting shall be provided using standard 4 foot lamps in sufficient quantity to maintain 30 fc 30" aff. Fixtures shall be equipped with diffusers. Lighting shall be switched beside the doors. An outdoor 70 watt HPS light fixture switched from beside the door shall also be provided at each door. One duplex receptacle shall be provided, minimum.

C. Wiring, incoming and outgoing, will be through the bottom. Access shall be provided as necessary for proper installation and maintenance. Also, an emergency lighting fixture shall be furnished and installed, wired into the housing lighting power circuit. All accessory equipment shall be wired to circuit breakers designated as "spares" on the Contract Drawings, and single-phase service upgraded as necessary.

D. A single entrance door shall be provided on each end of double wall construction with cellular neoprene gaskets, complete with brushed aluminum panic bar, hardware, and door closer. A wire meshed tempered safety glass window is required in the door. A door size of 36 inches by 7 feet nominal is required, at the location shown on the Contract Drawings. Should that door size not allow for proper equipment installation/removal, then a removable wall panel shall be required. A "Danger High Voltage" and "Authorized Personnel Only" sign shall be mounted on the exterior of the door and a drip shield installed over the door. The door shall have a lockset, and 5 keys shall be furnished the Owner.

E. The housing shall be supplied (but not necessarily built) by the MCC manufacturer and shall be custom built to fit the exact equipment specified. It is intended that the housing supplied be a specialized piece of equipment manufactured expressly for this application. The housing manufacturer shall certify/seal the Drawings prepared as Shop Drawings with an appropriate professional engineer's seals as required by local Code authorities.

F. The housing shall be anchored to the concrete foundation in accordance with manufacturer's recommendations.

G. The housing shall contain packaged through-wall heat pumps if the housing contains adjustable frequency drive units or other heat-sensitive/heat generating equipment. The units shall be sized to accommodate actual heat load anticipated. Two units shall be provided, each rated for half the load, and backup resistance heat shall be included.

H. *The arrangement of the VFD's and MCC may be altered from the arrangement shown on the Drawings. Overall building dimensions must not exceed a gross exterior footprint of 10 feet by 40 feet. If VFD's are to be cabled to the MCC feeder breakers, they shall be pre-wired from MCC to VFD, either in conduit, or in a cable tray, so that the Contractor doesn't have to wire them together in the field. If cable tray is used, be sure to provide code approved conductors for tray application. Tray shall be ladder style, aluminum, dimensions as required."*[ADD#4]

2.04 INDIVIDUALLY MOUNTED MOTOR CONTROL DEVICES (480, 240, OR 120 VOLT)

A. General

1. All motor control equipment shall be new and the product of 1 manufacturer. All individually mounted disconnects, push-button stations, latchout stations, starters, etc., indoors shall be mounted on a 1 inch galvanized unistrut, 1 inch Kindorf channel, or equal to provide an air space at rear. Outside mounted equipment shall utilize 1-inch aluminum strut as required in 16070.

B. Starters

1. General

a. All starters shall be of the voltage rating, type, and sized for the motor size shown in these Specifications and/or on the Contract Drawings. For enclosure type see the system operation description and/or the Contract Drawings. All starters shall be of the magnetic type. Should a piece of electrically driven equipment be furnished with a larger motor than shown on the Contract Drawings, the proper size combination starter shall be provided for the equipment supplied, at no extra cost to the Owner.

b. See the Contract Drawings for the auxiliary equipment to be furnished and/or Section 16900 - Controls of this division. **Maximum control voltage shall be 120 volts, a-c.** Minimum starter size shall be NEMA Size 1.

2. Overloads

a. Each starter shall have a thermal overload device in each ungrounded leg. The overload shall be of the "Ambient compensated Bi-metallic", thermal element type. All overloads shall be of the manual reset type and shall be reset without opening the starter enclosure. Heaters will be sized for the proper temperature rise of the motor that it is being used on. Heaters for general service shall be of the standard trip type. **Adjustable Overload Relay Thermal Units are not allowed.** All integral horsepower motors, 15 horsepower and over, require thermal elements embedded in the windings. See Motor Specifications, this division. Siemens-Allis overload relays shall be provided with a meter-sealed cover over relay adjustment controls.

3. Contactors

a. All contactors for motor starters shall be of the a-c magnetic type with "undervoltage" protection when used in conjunction with momentary contact push-button control and "undervoltage" release when used with maintained contact push-button control.

b. Contactor size shall be in accordance with NEMA Standards for the motor controlled and shall be horsepower rated. IEC rated equipment is not acceptable and shall be used as a basis for rejection of the equipment.

c. Contacts shall be of the heavy duty silver-to-silver type and shall be totally enclosed in individual arc quenching chambers. Contacts shall be easily accessible for replacement.

d. The contactor coil shall be of the vacuum impregnated or epoxy resin type, moisture resistant and corrosion proof.

C. Control Stations

1. General

a. Control stations shall be heavy duty, maintained or momentary contact type, as noted on the Contract Drawings. Contacts shall be silver alloy, double break type. The number and marking of controls shall be as shown on the Contract Drawings. Enclosures shall be NEMA 4X for indoor and outdoor mounting, unless otherwise noted on the Contract Drawings. All control stations shall operate on 120 volt, a-c maximum, unless otherwise designated on the Contract Drawings. "Latch-out" facilities shall be provided where called for in these Specifications and/or on the Contract Drawings.

2. Maintained Contact

a. Maintained contact control switches shall be marked "On" and "Off". The button pushed shall remain in and push the other button out until the other button is pushed. In general, they are to be used for hand control of motors which have to operate continuously and restart whenever power is off then resumed, without any manual operator. This is needed for motors which have to operate continuously in the absence of an operator.

3. Momentary Contact

a. Momentary contact control push-button switches shall be marked "start" and "stop". Pushbuttons shall spring out whenever pushed. If the circuit is dropped for any reason, operation cannot be resumed until a "start" push-button is pushed. In general, they are to be used for hand control of motors which are desired to operate intermittently in the presence of the operator and stop and start independently from more than one parallel control location.

D. Circuit Breakers

1. Circuit breakers shall be molded case type. Trip elements of multi-pole breakers shall be effectively insulated from one another. Multi-pole breakers shall be designed so that an overload on any one pole shall open all poles simultaneously.

2. The breaker operating mechanism shall be the quick-make, quick-break type and shall be entirely trip free to prevent the contacts being held in a closed position against a short circuit.

3. Breakers not used with motor starters shall be of the thermal magnetic type with a thermal bimetallic element for time delayed overload protection and a magnetic element for short circuit protection.

4. The breaker shall be trip indicating with the trip position midway between the "On" and "Off" positions.

5. Breakers for combination starters shall be 100 amp frame or larger. All breakers for combination starters shall have an adjustable magnetic trip element of the motor circuit protector type.

6. Breakers for combination starters shall be F frame or larger. All breakers shall have adjustable magnetic trip elements. Circuit breakers K frame and larger shall have interchangeable thermal-magnetic trip elements.

E. Safety Switches

1. Safety switches shall be of the heavy duty industrial, quick make, quick-break type. Ratings shall correspond to that of the equipment in which circuit it is used, fuses sized as shown on the Contract Drawings. All safety switches at motor locations are of the nonfused type unless otherwise noted.

2. Safety switches shall have a mechanical door interlock to prevent the door from being opened with the switch in the on position and facilities for locking it in the closed or open position. Enclosures for process areas and outside installations shall be NEMA 4X and enclosures for indoor, non-process areas, shall be NEMA 1, unless otherwise designated in Section 16900 of this division and/or on the Contract Drawings.

3. Safety switches shall be UL listed and shall conform to NEMA Standards. NEMA 4X enclosed safety switches where called for shall be stainless steel, or fiberglass.

4. NEMA 1 enclosed switches shall be phosphate coated or equivalent, code gauge steel with baked enamel finish.

F. Selector Switches

1. Hand-off-automatic type selector switches shall be of oil-tight construction and shall have 3 positions. The switch must not have a spring loaded return. It shall be of the "quick-make", "quick-break" type.

G. Manual Motor Starting Switches

1. Manual motor starting switches for the control of fractional horsepower motors shall be single pole, and shall be provided with a thermal heater of the correct size for the load controlled. Each starting switch shall be mounted where shown on the Contract Drawings. Where they are used for rotating equipment such as grinders, they shall be equipped with low voltage protection, and required manual reset after power failure. As an alternate to low voltage protection built-in, a "Safety Restart Plug" may be utilized, available from Mitchell Instrument Company.

H. Alarm Horns

1. Alarm horns, where called for on the Contract Drawings, shall be weatherproof, suitable for surface mounting and shall be provided with a silence button. Alarm horn shall be Edwards 876 series with 103dB at 10 feet, Federal Signal, or equal.

I. Timing Relays

1. Time delay relays shall have an adjustable timing range as shown on the Contract Drawings. The time delay shall be after energizing timer coil. Timing relays shall be Agastat, Square D, or equal.

2.05 TIMERS

A. Timers for various services required in the motor control equipment shall be Paragon, Tork or equal as indicated in control circuits shown on the Drawings.

B. Timers requiring tripping pins shall be supplied with enough pins to completely fill all locations on the dial face.

2.06 NETWORKABLE POWER METER

A. The power monitors shall be microprocessor-based with a base sampling frequency rate of at least 5.4 kHz. Measured parameters (volts, amps, and frequency) shall have accuracy in percent of reading of 0.1% and all calculated parameters shall be 0.1%.

B. Refresh rate for display and transmission of measured parameters shall be user configurable.

C. The metering unit shall contain self-powered status inputs capable of detecting dry contact closure.

D. The metering unit shall be capable of directly communicating via Ethernet without any modifications. Intermediate bridges or gateways are not acceptable.

E. The meter shall be supplied with a separate display unit. If a separate unit is supplied, the display shall be rated for NEMA 4 indoor use. The separate display unit shall be connected to the base unit utilizing Category 5 or Category 6 cable. All metering data, logs, and harmonic information contained within the meter shall be accessible via the display unit.

F. The following logs shall be contained within the unit with a nominal date/time stamping resolution of 0.01 seconds. The unit shall maintain all logs and configuration parameters in the event of loss of control power.

   1. Min/Max log capable of retaining and displaying the minimum- and maximum-recorded values for all real-time power system parameters.

   2. Snapshot log – A user configurable time/event driven based log.

   3. Event logs – Configurable to user defined measurable events. The unit shall be capable of retaining the most recent 100 events.

G. Setpoints. The metering unit shall have the ability to date/time stamp excursions beyond user-defined values for multiple parameters. These setpoint excursions shall be capable of triggering a log entry into the event log, triggering an oscillographic recording, and/or energizing one of the meter's onboard relays.

H. Oscillographic waveforms shall be available as (1) simultaneous, with all channels recorded for at least two cycles; and (2) user configurable with at least 75% cycles of pre-trigger data. Oscillographic recordings can be either manually triggered or internally triggered from a setpoint or event.

I. The metering unit and all accessories shall be listed and/or certified by UL, CSA, and CE and built in accordance with ISO 9000.

J. The following power monitoring device is approved – no substitutions:

   1. Allen Bradley Powermonitor-5000 M5

K. The unit shall have a flash upgradable firmware for higher power quality functionality.

L. The unit shall be directly accessible by a Human Machine Interface (HMI RSView) for data display.

M. The unit shall detect sags and swells and shall calculate amplitude and percent distortion for harmonics 1 – 127.

N. Provide necessary software for configuration and communication.

PART 3 - EXECUTION

3.01 INSTALLATION/APPLICATION/ERECTION

A. Motor Control Centers

1. Ends of MCC(s) shall be closed with 1/4" mesh hardware cloth and galvanized or aluminized insect screen or sill covers to prevent the entrance of rodents and large insects into the MCC housing(s).

2. Each MCC shall be provided with a 4" high concrete pad.

3. One inch air space (min.) shall be allowed between back of MCC(s) and wall surface.

4. Lifting-eyes in tops of MCC(s) section shall be removed (and retained) and the threaded openings closed with stainless cap screws and plastic washers or plastic seals provided for that purpose by the MCC(s) manufacturer.

5. In installations where conduit runs to electrical equipment emanate from the top of MCC(s) there shall be provided additional wiring space in the form of metal trough(s) of the same metal housing(s) dimensions and details. Trough(s) shall be provided by the manufacturer of the MCC(s).

B. Individually Mounted Motor Control Devices (480, 240, or 120 Volt)

1. Each motor disconnect shall be located as near as possible to its respective motor.

2. Remote control station at or near motor shall be mounted near its respective motor, adjacent to the motor disconnect.

3. All devices and equipment furnished under this section (electronic circuit monitors, power correction equipment, etc.) shall be programmed, configured, and calibrated by the manufacturer. Any settings required shall be as determined by the manufacturer. If coordination studies or power system analysis is required, it shall be performed by the manufacturer.

3.02 EXTRA STOCK/SPARE PARTS

A. Provide the following spare parts:

10 fuses of each type/amperage used

1 pilot light lamp for each pilot light socket assembly provided

1 control transformer for each size utilized

END OF SECTION

SECTION 16442 - PANELBOARDS

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. This section of the Technical Specifications includes furnishing all labor, materials, equipment, and incidentals required for the installation of all lighting and distribution panelboards as hereinafter specified and as shown on the Contract Drawings.

B. The panelboards for installation under this Contract shall be selected from the following types with the panel voltage and main sizes the determining factors. All panelboards shall be by the same manufacturer.

C. Circuit breakers of size and type shown on Contract Drawings and described herein shall be provided with the panelboards.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. "Square D", "Cutler Hammer", "General Electric Company," or equal.

2.02 EQUIPMENT

A. Rating

1. Panelboard ratings shall be as shown on the Contract Drawings. All panelboards shall be rated for the intended voltage.

B. Standards

1. Panelboards shall be in accordance with the Underwriter Laboratories, Inc. "Standard for Panelboards" and "Standard for Cabinets and Boxes" and shall be so labeled where procedures exist. Panelboards shall also comply with NEMA Standard for Panelboards and the National Electrical Code.

C. Panelboard Construction (NEMA 1)

1. Interiors

a. All interiors shall be completely factory assembled with circuit breakers, wire connectors, etc. All wire connectors, except screw terminals, shall be of the anti-turn solderless type and all shall be suitable for copper or aluminum wire of the sizes indicated.

b. Interiors shall be so designed that circuit breakers can be replaced without disturbing adjacent units and without removing the main bus connectors and shall be so designed that circuits may be changed without machining, drilling or tapping.

c. Branch circuits shall be arranged using double row construction except when narrow column panels are indicated. Branch circuits shall be numbered by the manufacturer.

d. A nameplate shall be provided listing panel type, number of circuit-breakers and ratings.

2. Bussing

a. Bus-bars for the mains shall be of copper. Full size neutral bars shall be included. Bus-bar taps for panels with single pole branches shall be arranged for sequence phasing of the branch circuit devices. Bussing shall be braced throughout to conform to industry standard practice governing short circuit stresses in panelboards. Phase bussing shall be full height without reduction. Cross connectors shall be copper.

b. Neutral bussing shall have a suitable lug for each outgoing feeder requiring a neutral connection.

c. Spaces for future circuit-breakers shall be bussed for the maximum device that can be fitted into them.

d. Separate neutral and ground bus shall be provided, insulated and isolated from each other.

3. Boxes

a. Recessed boxes shall be made from galvanized code gauge steel having multiple knockouts, unless otherwise noted. Surface mounted boxes shall be painted to match the trim. Boxes shall be of sufficient size to provide a minimum gutter space of 4 inches on all sides.

b. Surface mounted boxes shall have an internal and external finish as hereinafter specified. Surface mounted boxes shall be field punched for conduit entrances.

c. At least 4 interior mounting studs shall be provided.

4. Trims

a. Hinged doors covering all circuit-breaker handles shall be included in all panel trims.

b. Doors shall have semi flush type cylinder lock and catch, except that doors over 43 inches in height shall have a vault handle and 3-point catch, complete with lock, arranged to fasten door at top, bottom and center. Door hinges shall be concealed. Two keys shall be supplied for each lock. All locks shall be keyed alike; directory frame and card having a transparent cover shall be furnished on each door.

c. The trims shall be fabricated from code gauge sheet steel.

d. All exterior and interior steel surfaces of the panelboard shall be properly cleaned and finished with manufacturer's standard gray paint over a rust-inhibiting phosphatized coating. The finish paint shall be of a type to which field applied paint will adhere without cracking or peeling.

e. Trims for flush panels shall overlap the box by at least 3/4 inch all around. Surface trims shall have the same width and height as the box. Trims shall be fastened with quarter turn clamps.

D. Overcurrent Protective Devices (Circuit Breakers)

1. Panelboards shall be equipped with circuit-breakers with frame size and trip settings as shown on the Contract Drawings.

2. Circuit-breakers shall be molded case, bolt-in, thermal-magnetic trip.

3. Circuit-breakers used in 120/208 volt panelboards shall have an interrupting capacity of not less than 10,000 amperes, RMS symmetrical.

4. Circuit-breakers used in 480 volt panelboards shall have an interrupting capacity of not less than 22,000 amperes, RMS symmetrical.

5. GFCI (ground fault circuit interrupter) shall be provided for circuits where indicated on the Contract Drawings. GFCI units shall be 1-pole, 120 volt, molded case, bolt-on circuit-breakers, incorporating a solid state ground fault interrupter circuit insulated and isolated from the circuit-breaker mechanism. The unit shall be UL listed Class A Group I device (5 milliamp sensitivity, 25 millisecond trip time), and an interrupting capacity of 10,000 amperes RMS.

6. Trip elements of multi-pole breakers shall be effectively insulated from one another. Multi-pole breakers shall be designed so that an overload on any pole shall open all poles simultaneously.

7. The breaker operating mechanism shall be the quick-make, quick-break type and shall be entirely trip free to prevent the contacts being held in a closed position against a short circuit.

8. Breakers shall have a thermal bimetallic element for time delayed overload protection and a magnetic element for short circuit protection.

9. The breaker shall be trip indicating with the trip position midway between the "On" and "Off" positions.

10. Breakers for power distribution panels shall be F frame or larger. All breakers rated above 225 amps shall have interchangeable magnetic trip elements.

11. All breakers shall be UL listed, and conform to requirements of NEMA Standards.

E. Surge Protective Devices

1. See Section 16280 – Surge Protective Devices for panelboard SPD requirements.

PART 3 - EXECUTION

3.01 INSTALLATION/APPLICATION/ERECTION

A. Boxes for surface mounted panelboards shall be mounted so there is at least 1/2 inch air space between the box and the mounting surface.

B. Circuit directories shall be typed giving location and nature of load served.

C. Each panelboard shall be nameplated with plastic engraved nameplates stating the panel's name, voltage, and the name of panel serving the panel. Nameplates shall be secured by use of stainless steel screws.

END OF SECTION

SECTION 16446 - VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.01 REFERENCES

A. The drive shall be designed to meet the following specifications:

1. NEMA ICS 3.1 - Safety Standards for Construction and Guide for Selection, Installation and Operation of Adjustable Speed Drive Systems

2. NEMA 250 - Enclosures for Electrical Equipment

3. UL 508C – Underwriter's Laboratory

1.02 REGULATORY REQUIREMENTS

A. The drive shall conform to the following requirements:

1. IEC 146

2. EN Standard/CE marked for EMC directives

3.

Emissions	Immunity
EN 50081-1	EN 50082-1
EN 50081-2	EN 50082-2
EN 55011 Class A	IEC 801-1,2,3,4,6,8
EN 55011 Class B	(per EN 50082-1,2)

4. EN Standard/CE marked for Low Voltage directives

   EN 60204-1
   PREN 50178

5. IEC 801

6. The Manufacturer will furnish the product as listed and classified by Underwriter's Laboratories as suitable for the purpose specified and indicated.

1.03 QUALIFICATIONS

A. Manufacturer: The drive manufacturer shall have been in the drive business continuously for a minimum of 15 years and specialize in the design and manufacturing of PWM Adjustable Frequency Drives.

B. Support: The drive manufacturer shall maintain factory trained and authorized service facilities for their drives within 150 miles of the project and have a demonstrated record of service for at least the previous three years. Full-time support personnel shall be employed by the drive manufacturer.

C. Certification: All drives must be assembled at locations that are certified to the ISO-9001 Series of Quality Standards. This insures all quality and corrective action procedures are documented and implemented with a goal of Total Customer Satisfaction.

D. The drives must not generate harmonics to the line exceeding IEEE 519 limits of 5% of fundamental for current and voltage.

E. Floor space is critical, so any product offered by the Contractor must fit in the allocated space as shown on the Drawings.

1.04 SUBMITTALS

A. In addition to normal documentation, shop drawings shall include a harmonics analysis calculated at full load in accordance with Section 8 of IEEE 519. The analysis shall show that sufficient filtering has been provided to limit the total harmonic distortion (THD) to 5% for current and voltage.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. "Allen Bradley, Powerflex 750, 18 pulse", or equal.

2.02 RATINGS

A. Input Power: The drive is self adjustable to accept an input voltage range between 200-240/380-480/500-600VAC, three phase +/-10%.

B. Displacement power factor shall range between 1.0 and 0.95, lagging, over the entire speed range. The efficiency of the drive shall be a minimum of 97% at full load and speed.

C. Environment: Storage ambient temperature range: -40 to 70 C (-40 to 158 F). Operating ambient temperature range: 0 to 40 C (0 to 109 F) without derating. The relative humidity range is 5% to 95% non-condensing. Enclosure rated NEMA 12.

D. Operating elevation: up to 1000 Meters (3,300ft) without derating.

E. Output Power: The output voltage is adjustable from 0 to rated input voltage. The output frequency range is adjustable from 0 to 400 Hz. The inverter section will produce a pulse width modulated (PWM) waveform using latest generation IGBTs (18 pulse drive).

F. Drives shall be designed to minimize reflected wave.

2.03 DESIGN

A. Hardware: The drive hardware shall employ the following power components:

1. Diode or fully gated bridge on the input.
2. DC bus inductor on all ratings 5.5kW (7.5HP) or greater.
3. Switching logic power supply operating from the DC bus.
4. Phase to phase and phase to ground MOV protection.
5. Gold plated plug-in connections on printed circuit boards.
6. Microprocessor based inverter logic isolated from power circuits.
7. Latest generation IGBT inverter section.
8. Inverter section shall not require commutation capacitors.

9. Customer Interface common for all horsepower ratings. Interface shall include an LCD digital display, programming keypad and operator keys option.

10. Main Control Board common for 15 HP and up.

11. Common control connection for all ratings.

12. Optimized for 4kHz carrier frequency at 44kW (60HP) or less, and 2kHz at 55kW (75 HP) and larger.

13. Peripheral Interface to enable attaching common options.

14. NEMA 1 enclosed with mechanical ventilation and filter kit.

15. The VFD shall be integrated with the transformer.

16. Enclosure shall be painted ANSI gray to match other electrical cabinets.

B. Control Logic: The drive shall be programmable or self adjusting for operation under the following conditions:

1. Operate drive with motor disconnected.

2. Controlled shut down, when properly fused, with no component failure in the event of an output phase to phase or phase to ground short circuit and annunciation of the fault condition.

3. Adjustable PWM carrier frequency within a range of 2-8kHz.

4. Selectable Sensorless Vector or V/Hz mode.

5. Selectable for variable or constant torque loads. Selection of variable torque provides 115% of rated VT current for up to one minute. Selection of constant torque provides 150% of rated CT current for up to one minute.

6. Multiple programmable stop modes including - Ramp, Coast, DC-Brake, Ramp-to-Hold and S-curve.

7. Multiple acceleration and deceleration rates.

8. All adjustments to be made with the door closed.

9. Adjustable output frequency up to 400Hz.

C. Power Conditioning

1. The drive shall be designed to operate on an AC line which may contain line notching and up to 10% harmonic distortion. An 18 pulse input isolation transformer shall be required.

2.04 FEATURES

A. Interface: The drive shall provide a removable Human Interface Module with integral display to show drive operating conditions, adjustments and fault indications. The display shall be removable under power without causing a fault and is visible and operable without opening the enclosure door. The display shall consist of 2 lines of 16 character alphanumeric, backlit LCD with the display being configurable for simultaneously displaying two values using customized multi-lingual text and user scaled units. The module shall provide LED indication of drive direction and commanded direction. The display shall be capable of remote

mounting by means of cable connection up to 10 meters (33ft) from the drive and is capable of being used as a hand-held terminal.

B. Control Mode: Programming shall provide the ability to select sensorless vector or v/hz mode. The sensorless vector mode shall use motor nameplate data plus motor operating data, such as IR drop, nominal flux current and flux up time. The volts per hertz mode shall be able to be programmed for squared, cubed, straight line, pre programmed or full custom patterns.

C. Current Limit: Programmable current limit shall be available from 20% to 160% of constant torque rating. Current limit shall be active for all drive states; accelerating, constant speed and decelerating. The drive shall employ PI regulation with an adjustable gain for smooth transition in and out of current limit.

D. Acceleration/Deceleration: Accel/Decel settings shall provide separate adjustments to allow either setting to be adjusted from 0 seconds to 3600 seconds. A second set of remotely selectable Accel/Decel settings shall be accessible with Control Interface option. An adaptive current limit circuit shall be able to be disabled in programming for fast acceleration of low inertia loads.

E. Speed Regulation: The programmable speed regulation modes shall include the following:

1. Open Loop
2. Slip Compensation with 0.5% speed regulation
3. Droop - Negative Slip Compensation with 0.5% speed regulation
4. Traverse Function
5. Closed loop encoder feedback with 0.1% speed regulation
6. Process PI control

F. Speed Profiles: Programming capability shall allow the user to produce speed profiles with linear acceleration/deceleration or "S-Curve" profiles that provide changing accel/decel rates. S-Curve profiles shall be selectable for fixed or adjustable values.

G. Adjustments: The digital interface shall be provided for all set-up, operation and adjustment settings. All adjustments are shall be stored in nonvolatile memory (EEPROM). Potentiometer adjustments are not acceptable. The drive shall provide EEPROM memory for factory default values.

H. Process PI Control: An internal process PI regulator shall have both proportional and integral gain adjustments as well as error inversion and output clamping functions. The feedback may be configured for normal or square root functions. If the feedback indicates that the process is moving away from the setpoint, the regulator will adjust the drive output until the feedback equals the reference. Process control shall be enabled or disabled with a hardwire input. Transitioning in and out of process control shall be able to be tuned for faster response by preloading the integrator. Protection shall be provided for a loss of feedback or reference signal.

I. Fault Reset/Run: The drive shall have the ability to conduct up to nine automatic fault reset and restarts following a fault condition before locking out and requiring manual restart. The automatic mode is not applicable to a ground fault, shorted output faults and other internal microprocessor faults. The time between restarts shall be adjustable from 0.5 seconds to 30 seconds.

J. Skip Frequencies: The drive shall contain three adjustable set points that lock out continuous operation at frequencies which may produce mechanical resonance. The set points shall have a bandwidth adjustable from 0Hz to 15Hz.

K. Run On Power Up: A user programmable restart function shall be provided to automatically restart the equipment after restoration of power after an outage. A maintained 2-wire start input is required for this function.

L. Line Loss Restart: This programmable function shall be provided to select the reconnect mode of the drive after recovery from a line loss condition. The reconnect modes shall be B Last Speed, Speed Search, Track Volts, or Use Encoder. Disabling this feature shall force the drive to start from zero hertz.

M. Fault Memory: The last four faults as well as operating frequency, drive status and power mode shall be stored at the time of fault. Information shall be maintained in the event of a power loss.

N. Overload Protection: The drive shall provide Class 20 motor overload protection investigated by UL to comply with N.E.C. Article 430. Overload protection shall be speed sensitive and adjustable for motors with speed ranges of 2:1, 4:1 and 10:1. A viewable parameter shall store the overload usage in percent. An alarm bit can be used to adjust a process to eliminate an overload trip.

O. Auto Economizer: This feature shall automatically reduce the output voltage when the drive is operating in an idle mode (drive output current less than programmed motor FLA). The voltage shall be reduced to minimize flux current in a lightly loaded motor thus reducing kW usage. If the load increases, the drive shall automatically return to normal operation.

P. Terminal Blocks: Separate terminal blocks shall be provided for control and power wiring.

Q. Flying Start: The drive is shall be capable of determining the speed and direction of a spinning motor and adjust its output to "pick-up" the motor at the rotating speed. The flying start feature shall be operable with or without encoder feedback.

R. Ride Through: The control logic shall be capable of "riding through" a power outage of up to 2 seconds in duration.

S. Analog Output: An output signal shall be provided and be jumper selectable for 0 - 10V DC or 0 - 20 mA which is user programmable such that it is proportional to one of 13 process parameters including output frequency, output current, encoder feedback, output power and others. A programmable offset shall be provided to allow modification of the analog output to obtain 2 - 10V DC or 4 - 20 mA. Programmable gain adjustments for both upper and lower settings shall allow for system calibration.

T. Reference Signals: The drive shall be capable of the following input reference signals:

Digital pulse input	Digital MOP
Remote potentiometer	Serial
10V DC	HIM (Program/Control panel)
20 Ma	

U. Loss of Reference: In the event of loss of the 4 - 20 mA reference signal, the drive shall be user programmable to the following:

Fault and stop
Alarm and maintain last reference within 10%
Alarm and go to preset speed
Alarm and go to minimum speed
Alarm and go to maximum speed
Active for Process PI reference or feedback

V. Digital I/O: Contact output ratings shall be 115V AC/30V DC, 5.0 Amp resistive, 2.0 Amp inductive. All four contacts provided shall be programmable to 17 different conditions. Factory settings shall be as follows:

Form A Run contact
Form C Fault contact
Form C Alarm contact
Form A at Speed contact

W. Operator Devices, and Control Interface: Provide start and stop controls integrally with the drive. Also provide control interface cards as required to accommodate the external control devices shown in Control Circuits.

X. Provide an Ethernet interface board for communication with the plant SCADA system.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Anchor all cabinetry firmly to the foundation.

B. Comply with manufacturer's recommendations, except as modified herein.

C. Drives shall be adjusted such that maximum speed is motor nameplate RPM, and minimum speed is just high enough to provide motor driven equipment cooling.

3.02 START-UP, TRAINING, AND TESTING

A. The drive manufacturer shall provide factory authorized, trained service personnel for start-up and testing. Upon successful completion of installation and testing, training shall be provided in accordance with 16050.

3.03 TOOLS AND SPARE PARTS

A. Any special tools required for normal operation and maintenance shall be provided by the equipment manufacturer.

B. Furnish the following spare parts:

Ten fuses for each control power type used.

One set of three main power fuses of each size provided on the project.

Six spare filters per VFD.

3.04 HARMONICS FIELD TESTING/VERIFICATION

A. Field measurement of the harmonic indices shall be performed by the Contractor at unit full load using a harmonic analyzer with CTs with rated accuracy at 400 hertz. Harmonic indices shall be measured at the PCC. Tests shall prove that sufficient filtering has been provided to limit the harmonic distortion to limits set by IEEE 519. Results shall be tabulated and test results submitted to the Engineer for acceptance.

END OF SECTION

SECTION 16460 - SMALL POWER AND MISCELLANEOUS TRANSFORMERS

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. Transformer locations and size shall be as shown on the Contract Drawings, as specified herein.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. "Square D", "Cutler Hammer", or approved equal.

2.02 FABRICATION

A. General Purpose Dry-Type Transformers

1. Single phase transformers shall be 480 volt primary and 120/240 volt secondary. Three phase transformers shall be 480 volts delta primary and 208 Y/120 or 240 volt delta secondary. Transformers 25 KVA and larger shall have a minimum of 4 (2 above, 2 below) 2 1/2 percent full capacity primary taps.

2. Transformers shall be 150 degrees Celsius temperature rise above a 40 degrees Celsius ambient. All insulating materials are to be in accordance with the latest NEMA Standards for a 220 degrees Celsius UL recognized insulation system.

3. Transformer coils shall be of the continuous wire wound construction and shall be impregnated with non-hygroscopic, thermo-setting varnish. The coils shall also have a final wrap of electrical insulating material to prevent mechanical injury to the wire as well as increasing the electrical breakdown strength.

4. All cores shall be constructed of high grade, non-aging silicon steel with high magnetic permeability, and low hysteresis and eddy current losses. Magnetic flux densities are to be kept well below the saturation point. The core laminations shall be clamped together with steel angles. The completed core and coil shall then be bolted to the base of the enclosure but isolated from the base by means of rubber, vibration absorbing mounts. There shall be no metal-to-metal contact between the core and coil to the enclosure. On transformers 500 KVA and smaller, the vibration isolation system shall be designed to provide a permanent fastening of the core and coil to the enclosure. To further facilitate vibration and noise isolation, the final section of conduit to the transformer shall be flexible.

5. Transformers 25 KVA and larger shall be in heavy gauge, sheet steel, ventilated enclosures. The ventilating openings shall be designed to prevent accidental access to live parts in accordance with UL, NEMA, and National Electrical Code Standards for ventilated enclosures. Transformers 25 KVA through 75 KVA shall be designed so they can either be floor or wall mounted. Above 75 KVA they shall be of the floor mounted design.

6. The entire transformer enclosure shall be degreased, cleaned, phosphatized, primed, and finished in the same color as the motor control equipment. For more details see Division 9 of these Specifications.

7. The maximum temperature of the top of the enclosure shall not exceed 50 degrees Celsius rise above a 40 degrees Celsius ambient.

8. The core of the transformer shall be visibly grounded to the enclosure by means of a flexible grounding conductor sized in accordance with NEMA and NEC Standards.

9. The transformer shall be marked "DANGER HIGH VOLTAGE" with labels specified in the section on marking, this Division.

10. The transformers shall be manufactured to requirements of applicable standards, especially as they apply to noise level and surface temperatures.

PART 3 - EXECUTION

3.01 INSTALLATION / APPLICATION / ERECTION

A. Transformers shall be rigidly mounted to the structure or the foundation in the case of freestanding units.

B. Transformers shall be megger tested prior to energization.

C. Transformers with taps shall be adjusted to supply the nominal service voltage required on the secondary.

D. Transformers shall be installed in accordance with NEC requirements and manufacturer recommendations.

END OF SECTION

SECTION 16495 - SWITCHBOARD MATTING

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. Switchboard matting shall be furnished by the Contractor and placed in front of all power distribution and control equipment.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Switchboard matting shall be W.H. Salisbury & Company, Wearwell, Erico, or equal.

2.02 MATERIALS

A. Switchboard matting shall be nonconductive with a minimum of 40,000 volts dielectric strength. The mat shall have a corrugated, non-slip surface and shall be a minimum of 1/4 inch thick. Width shall be 36 inches and length shall be as required at each location. The mat shall be black in color, ozone and oil resistant, and manufactured to meet all applicable ANSI/ASTM standards.

PART 3 - EXECUTION

Not Applicable.

END OF SECTION

SECTION 16500 - LIGHTING

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. The specific characteristics of the light fixtures to be furnished and installed shall be as detailed in the Contract Drawings. Should a fixture of a different type or manufacturer than that specified be submitted for the Engineer's review, it will be compared to that specified on: construction, dimensions, and photometrics. Failure to compare equally to what was specified will be grounds for rejection.

B. The Contractor shall be prepared to submit sample equipment for appraisal when requested by the Engineer, and shall assume all transportation costs involved in the shipment and return of samples. All sample fixtures submitted shall be provided with lamps and shall be wired with cord and plug, to facilitate lighting for appraisal.

PART 2 - PRODUCTS

2.01 BALLASTS

A. All ballasts shall have built in thermal protection and be of the high power factor type built to conform to UL and ANSI standards (as attested by CBM certification).

B. Where shown on the Contract Drawings premium efficiency ballasts shall be provided with luminaires.

2.02 LUMINAIRES

A. All fixtures shall be delivered complete with suspension and mounting accessories, ballasts, diffusers, reflectors, etc., all wired and assembled. All accessory wiring shall be furnished and installed as shown on the Contract Drawings.

B. All steel supports required for luminaires in addition to that furnished under the general building construction shall be furnished and installed by the Contractor.

C. When fixtures are noted to be installed flush, they shall be complete with the proper accessories for installing in the particular ceiling involved. All flush mounted fixtures shall be supported from the structure and shall not be dependent on the hung ceilings for their support.

D. All outside luminaires shall be a type that will prevent insect accumulation inside the luminaire.

E. Exterior luminaires shall be weatherproof and rustproof.

F. Luminaires for vaults and pipe galleries shall be watertight and rustproof. Explosionproof where the atmosphere is classified.

G. Luminaire wire shall be fixture type of non-asbestos construction.

2.03 LAMPS

A. Fluorescent lamps shall have standard cool white (CW) color characteristics unless otherwise indicated, and shall be of the type that will not require starter switches.

2.04 LED TANK WALL WASH LUMINAIRES

A. Color changing LED luminaires shall be provided to illuminate the vertical surface of the storage tank as detailed in the Drawings. Provide a standalone lighting controller for programming scenes to be mounted inside the new electrical building.

PART 3 - EXECUTION

3.01 INSTALLATION/APPLICATION/ERECTION

A. General

1. The Contractor shall furnish all light fixtures, lighting equipment, components, hangers, etc., as shown on the Contract Drawings and shall install them at the locations shown on the Contract Drawings.

2. All fixture wiring shall be in conformance with the latest revision of the NEC and UL standards.

3. Lamps of the proper type, wattage and voltage rating shall be delivered to the project in the original cartons and installed in the fixtures just prior to the completion of the project, with spare lamps as listed on the Contract Drawings.

4. All incandescent and fluorescent lamps used during the building construction in contract lighting fixtures prior to 2 weeks from the completion of the work shall be removed and replaced with new lamps.

5. Locations of fixtures shall be coordinated with Engineer's reflected ceiling plans where they exist. Any conflicts between electrical plans and Engineer's reflected ceiling plans, the reflected plans shall override.

B. Luminaires

1. Fixtures shall be rigidly mounted against the surface of the ceiling unless otherwise noted on the Contract Drawings. Conduit runs to and between fixtures shall be rigid metallic type. Use of flexible conduit for connection to fixtures is prohibited, except where concealed above a suspended ceiling.

2. All ferrous metal surfaces of fixtures and plaster frames shall be treated and given rust-inhibiting and finish coat adherence properties before final enamel coats are applied. Finish enamel coat shall be baked on at approximately 320 degrees Fahrenheit.

3. Similar fixtures in each room or area shall be installed with bottom of fixtures at same elevation, unless otherwise noted.

4. Minimum wire size shall be AWG No. 10 for runs over 75 feet.

5. Outlets shall be as specified herein and shall be suitable for the installation conditions encountered.

6. Flexible fixture hangers shall be used for all pendant mounted fixtures.

7. Conduit run in areas with hung ceilings shall be installed in the space above the hung ceiling as close to the structure as possible. Conduits and junction boxes shall be supported from the structure.

8. No light fixtures shall be hung or installed until after painting is completed, however, temporary lighting shall be provided by the Contractor. Fixtures in suspended ceilings shall be fastened to the main tees of the ceiling grid.

9. All fixtures shall be left in a clean condition, free of dirt and defects, before acceptance by the Engineer.

B. LED Control System

1. The lighting supplier shall provide factory technicians for startup services and commissioning. Luminaires shall be aimed, and the Owner shall be trained on how to operate and program the local control system. At a minimum, the startup technician shall pre-program 5 different scenes in the controller so the Owner may default to these should they not desire to program their own scenes.

END OF SECTION

SECTION 16620 – PACKAGED ENGINE GENERATOR SYSTEMS

PART 1 - GENERAL

1.01 REQUIREMENTS

A. The Equipment Supplier shall provide standby power engine generator set complete with exhaust silencer, batteries, charger, and wp enclosure.

B. It is the intent under this Contract to require a complete package in every detail whether or not specified. Consequently, the Equipment Supplier is responsible for all details, devices, accessories and special construction necessary to properly install, adjust, test, and place in successful and continuous operation the engine-generator set.

C. Use materials which are new, unused, and as specified, or, if not specifically indicated, the best and most suitable of their kinds for the purpose intended, and for the design and expected conditions of service, subject to the approval of the Engineer.

D. All materials used must bear the inspection labels of the Underwriter's Laboratories, if the material is of a class inspected by the Laboratory.

E. Unless otherwise indicated, the materials to be provided under this Specification shall be the products of manufacturers regularly engaged in the production of all such items and shall be the manufacturer's latest design. The products shall conform to the applicable standards of UL and NEMA, unless specified otherwise. International Electrotechnical Commission (IEC) standards are not recognized. Equipment designed, manufactured, and labeled in compliance with IEC standards is not acceptable.

F. The engine generator sets shall fully comply with all current Environmental Protection Agency (EPA) emission regulations including, but not limited to, the requirements specific to mobile non-road generator sets. The engine generator set(s) must meet the EPA new source performance requirements required at the time the engine generator set(s) submittal is approved by the Engineer. Engines manufactured previous to the submittal approval date that do not meet the current regulated emissions levels are not acceptable.

1.02 CODES AND STANDARDS

A. The generator set shall be listed to UL 2200 or submitted to an independent third party certification process to verify compliance as installed.

B. The generator set shall conform to the requirements of the following codes and standards:

1. CSA C22.2, No. 14-M91 Industrial Control Equipment.

2. EN50082-2, Electromagnetic Compatibility-Generic Immunity Requirements, Part 2: Industrial.

3. EN55011, Limits and Methods of Measurement of Radio Interference Characteristics of Industrial, Scientific and Medical Equipment.

4. IEC8528 part 4, Control Systems for Generator Sets.

5. IEC Std 61000-2 and 61000-3 for susceptibility, 61000-6 radiated and conducted electromagnetic emissions.

6. IEEE446 Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications.

7. NFPA 70, National Electrical Code, Equipment shall be suitable for use in systems in compliance to Article 700, 701, and 702.

8. NFPA 110, Emergency and Standby Power Systems. The generator set shall meet all requirements for Level 1 systems. Level 1 prototype tests required by this standard shall have been performed on a complete and functional unit. Component level type tests will not substitute for this requirement.

1.03 TESTING

A. All tests shall be performed in accordance with the requirements of the General Conditions. The following tests are required:

1. Witnessed Shop Tests

   a. None required.

2. Certified Shop Tests and Reports

   a. Fully test the engine-generator set with all accessories in the manufacturer's plant before shipment; test at various loadings from full load to no load, and at such other conditions as to properly establish that all requirements have been met. Tests shall be conducted through the use of balanced, three-phase, dry-type, resistive load banks. Obtain Engineer's approval before shipment is made.

   b. Submit two (2) certified copies of all test reports.

3. Field Tests

   a. Startup and field testing shall take place at the distributor's local facility.

   b. In the presence of the Owner's representative inspect, adjust and test the entire system and leave in good working order. Tests shall be conducted through the use of balanced, three-phase, dry-type, resistive load banks. Notify the Owner by letter approving the equipment as ready for test two (2) weeks prior to the running of the specified field test. Field tests shall be conducted after the entire system is completely installed. Field tests shall include, but are not limited to, the silencer, radiators, engine-generators, and all other equipment included in the complete system.

   c. Conduct a continuous test run of at least four (4) consecutive hours without shutdown for the set under the following conditions of load.

      2 hours, full load
      1/2 hour, 3/4 load
      1/2 hour, 1/2 load
      1/2 hour, 1/4 load
      1/2 hour, no load

   d. Record complete test data for frequency, amperes, volts, power factor, exhaust temperature, coolant temperature, and oil pressure every 15 minutes during the continuous run test. If any failures and/or shutdowns occur during this four (4) hour test, the problems shall be fixed and the test shall be restarted. The test shall not be considered complete until the generator has operated for four (4) consecutive hours without any shutdowns under the conditions listed above.

1.04 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions the Equipment Supplier shall obtain from the equipment manufacturer and submit the following:

1. Shop Drawings
2. Spare Parts List
3. Special Tools List
4. Reports of Certified Shop and Field Tests
5. Operation and Maintenance Manuals

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

1.05 SHOP DRAWINGS

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

B. Partial, incomplete or illegible submittals will be returned to the Equipment Supplier without review for resubmittal.

C. Shop drawings for each engine-generator set shall include but not be limited to:

1. A Compliance, Deviations, and Exceptions (CD&E) letter. If the shop drawings are submitted without this CD&E letter, the submittal will be rejected. The letter shall include all comments, deviations and exceptions taken to the Specifications by the Equipment Supplier AND Equipment Manufacturer. This letter shall include a copy of this specification section. In the left margin beside each and every paragraph/item, a letter "C", "D", or "E" shall be typed or written in. The letter "C" shall be for full compliance with the requirement. The letter "D" shall be for a deviation from the requirement. The letter "E" shall be for taking exception to a requirement. Any requirements with the letter "D" or "E" beside them shall be provided with a full typewritten explanation of the deviation/exception. Handwritten explanation of the deviations/exceptions is not acceptable.

2. Standard manufacturers printed specification sheet showing critical engine and generator set specifications including the following:

   a. Dimensions, and weights

   b. Guaranteed fuel consumption at 25%, 50%, 75% and 100% of full rated load

   c. Engine bhp available

   d. Engine jacket water heat rejection

   e. Exhaust flow rate and temperature at 100% of rated load

   f. Ventilation and combustion air requirements

   g. Exhaust backpressure limitation

   h. Liquid refill capacities

i. Generator efficiency at 50%, 75%, and 100% load

j. Telephone Interference Factor (TIF)

k. Harmonic waveform distortion

l. Type of winding insulation and generator temperature rise

m. Voltage regulation characteristics

n. Guaranteed noise levels

o. Per unit subtransient impedance X" and X/R ratios for positive, negative, and zero sequences

p. Transient reactance (Xd')

q. Synchronous reactance (Xd)

r. Sub transient time constant (Td")

s. Transient time constant (Td)

t. DC time constant (Tdc)

u. Decrement curve

3. Engine and generator material composition and construction.

4. Standard manufacturer's printed warranty statement of the engine and generator set showing single source responsibility by the engine manufacturer.

5. Generator control panel equipment and features. Include a written explanation of the auto start/stop logic and operation.

6. Engine-generator set and accessory catalog data sheets including, but not limited to, the vibration isolators, flexible exhaust coupling, exhaust silencer, batteries, battery charger, main line circuit breaker and enclosure, circuit breaker trip units, engine manufacturers shutdown contactors, fuel lines, fuel level devices, jacket coolant heater, generator strip heater. Include radiator data sheets describing the materials of construction for the radiator core, fan and frame. Include a detailed statement concerning non-engine-generator set manufacturer's warranty policies, Dealer's responsibility, and duration of policy.

7. Standard dealer preventative maintenance contract for review and possible adoption under a separate Contract. Dealer must have existing contracts and personnel and contractual detailed performance information available.

8. Normal operating ranges for systems temperature, pressure and speed.

9. Manufacturer's part number for the engine and generator operation guide, parts book, service manual, warranty policy, and installation guide.

10. Location of other similar units.

11. Phone numbers of twenty-four (24) hour products support contacts and locations.

12. Drawing showing right hand, left hand, and top views of proposed assembly; battery rack, isolators, exhaust silencer, conduit stub up locations, and flexible fittings; wiring

schematics, interconnection diagrams (point to point), and written description of engine generator controls and alarm circuits.

13. Control panel layout drawings and wiring diagrams.

14. Drawings and specifications for base-mounted fuel storage tank with accessories and leak detection system.

15. Detailed drawings showing plan, front, and side views as well as appropriate section views of the weatherproof, engine-generator enclosure. Include product data sheets for all appurtenances (e.g. exhaust fan, thermostat, lighting, switches, receptacles, combination power unit, etc.) to be furnished and installed in the enclosure. Drawings shall be of sufficient detail to assure proper installation by the Equipment Supplier.

D. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these Specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items the Equipment Supplier intends to provide are acceptable and shall be submitted.

1.06 OPERATION AND MAINTENANCE MANUALS

A. The Equipment Supplier shall submit operation and maintenance manuals in accordance with the procedures and requirements set forth in the General Conditions.

B. Furnish identical bound instruction manuals (quantities as defined in Division 1) covering operating procedures, lubrication, and maintenance requirements of all equipment furnished under this Item. Include wiring diagrams, drawings, product data sheets, parts lists, and other necessary data. Number or otherwise clearly identify all parts to facilitate ordering of replacements. Exclude data not pertinent to this installation.

1.07 TOOLS, SUPPLIES, AND SPARE PARTS

A. The engine-generator systems shall be furnished with all special tools necessary to disassemble, service, repair and adjust the equipment as part of a regular maintenance program. All spare parts as recommended by the equipment manufacturer shall be furnished to the Owner by the Equipment Supplier.

The Equipment Supplier shall furnish the following spare parts for each engine-generator set:

No. Required	Description
1	Set of Air Filters
1	Set of Lube Oil Filters

B. The spare parts shall be packed in containers suitable for long term storage, bearing labels clearly designating the contents and the pieces of equipment for which they are intended.

C. Spare parts shall be delivered at the same time as the equipment to which they pertain. The Equipment Supplier shall properly store and safeguard such spare parts until completion of the work, at which time they shall be delivered to the Owner.

D. Spare parts list, included with the shop drawing submittal, shall indicate specific sizes, quantities, and part numbers of the items to be furnished. Terms such as "1 lot of packing material" are not acceptable.

E. Parts shall be completely identified with a numerical system to facilitate parts inventory control and stocking. Each part shall be properly identified by a separate number. Those parts which are identical for more than one size, shall have the same parts number.

F. The dealer shall have sufficient parts inventory to maintain over-the-counter availability of at least 90% of any required part and 100% availability within 48 hours.

1.08 SERVICE OF MANUFACTURER'S REPRESENTATIVE

A. The Equipment Supplier shall provide the services of a qualified manufacturer's factory-trained technical representative to provide training as specified.

B. The engine-generator set manufacturer shall have a local authorized dealer who can provide factory trained service, the required stock of replacement parts, technical assistance, and warranty administration for all components supplied by the dealer.

1.09 IDENTIFICATION

A. Each engine-generator set shall be identified with the identification number specified by the Owner. A nameplate shall be securely affixed in a conspicuous place on the generator.

1.10 TRAINING

A. The Equipment Supplier shall provide training for Owner personnel. Training shall be conducted by the manufacturer's factory trained specialists who shall instruct Owner personnel in operation and maintenance of all equipment provided under this Section.

B. The generator shall be load bank tested for a minimum of 30 minutes during field training.

1.11 WARRANTY TERMS

A. The manufacturer's and dealer's standard warranty shall in no event be for a period of less than one (1) year or two-thousand (2,000) hours of operation, whichever comes first, from date of initial start-up of the system and shall include repair labor, travel expense necessary for repairs at the jobsite, and expendables (lubricating oil, filters, antifreeze, and other service items made unusable by the defect) used during the course of repair. Submittals received without written warranties as specified shall be rejected in their entirety.

1.12 SOUND ATTENUATION

A. Extreme care shall be exercised in providing equipment for and setting the engine-generator in place to guard against excessive noise transmission and vibrations. Fasten to the underside of the skids seismically-rated spring type isolators.

B. The engine-generator enclosure shall be designed, furnished, and installed to reduce source noise to 78 dB(A) as measured at seven (7) meters from the enclosure.

2. The switch shall be NEMA 1 enclosed, ASCO Series 300, Russelectric, or equal.

B. Sequence of Operation

1. Engine starting contacts shall be provided to start the generating plant if any phase of the normal source drops below 80 percent of rated voltage (adjustable), after a non-adjustable time delay period of 3 seconds, to allow for momentary dips. The transfer switch shall transfer to emergency as soon as the generator voltage and frequency have reached 90 percent of rated voltage (adjustable) and after an adjustable time delay period of 0-30 minutes shall delay retransfer to normal power until it has had time to stabilize. If the emergency power source should fail during the time delay period, the time delay shall be bypassed, and the switch shall return immediately to the normal source. After the switch is retransferred to normal, the engine-generator shall be allowed to operate at no load for an adjustable period of time (0-5 minutes) to allow it to cool before shutdown. The transfer switch shall include a key operated test switch (provide the Owner 5 keys) to simulate normal power failure (maintained contact), pilot lights on the cabinet door to indicate the switch closed on normal or emergency, and 2 auxiliary contacts on the main shaft: one closed on normal, the other closed on emergency. A selector switch shall be provided so that the switch may be either manually transferred or automatically transferred. A pushbutton manual operator shall be provided so that the plant operator will not have to manually throw the switch by lever. In addition, 1 set of relay contacts shall be provided in the automatic transfer switch that is normally open and closes upon transfer of the switch to emergency position, to signal an alarm at the SCADA system. All relays, timers, control wiring and accessories to be front accessible.

C. Automatic Transfer Switch Commissioning

1. After the installation is completed, the transfer switch shall be tested by simulating a power failure and having the generator automatically start, come up to speed, and assume the available load at the site. All signals and timers shall be verified. At the end of the simulation, the load should transfer back, engine run through cooldown and shutoff automatically. Manual pushbutton control should also be checked."

WESTECH
Process Equipment. Process Driven.

Thursday, September 18, 2014

Mr. Joe Henry, PE
GRW
801 Corporate Drive
Lexington, KY 40503

RE: Town Branch Wet Weather Storage Facility
Lexington-Fayette Urban County Government
Division of Water Quality
Remedial Measures Plan ID No. G2-TB-1
LFUCG Bid No. 137-2014
Specification Section 11252 – Vertical Mounted Mechanical Screen

Dear Mr. Henry,

WesTech acknowledges that LFUCG is specifying the proposed equipment as a sole source item for the specific project and thus we agree to the following additional terms and conditions for supplying the specified equipment per our final cost proposal.

- Proposal price is guaranteed to LFUCG for use by all contractors bidding the specified project and will not change to any general contractor.
- Proposal price is guaranteed for the duration of the contract and will not change if the project proceeds in an orderly manner.
- Proposal price includes all costs for the equipment including O&M submittal, startup and training, and warranty per the related specifications and drawings in the Contract Documents.
- WesTech acknowledges and agrees that the purchase order for the specified equipment will be issued by the general contractor to which the LFUCG awards the contract for the construction of the specified project, and that the general contractor shall be solely responsible for payment.

Please do not hesitate to contact me if you have any questions or require additional information. We look forward to working with you on this project to provide the Lexington-Fayette Urban County Government the best possible treatment solution.

Sincerely yours,
WesTech Engineering, Inc.

James R. Hanson, VP
National Sales Manager

c: Katie Avera, Eco-Tech, Inc.

An Employee-Owned Company

3665 S. West Temple, Salt Lake City, UT 84115 Tel: 801.265.1000 Fax: 801.265.1080 www.westech-inc.com

Conformance Set

RE: Town Branch Wet Weather Storage Facility
Lexington-Fayette Urban County Government
Division of Water Quality
Remedial Measures Plan ID No. G2-TB-1
LFUCG Bid No. 137-2014
Specification Section 11252 – Vertical Mounted Mechanical Screen

State of Utah)

§

County of Salt Lake)

On this 18th day of September, 2014, before me Catarina N. Garcia, a notary public, appeared James R. Hanson, personally known to me to be the person whose name is subscribed to on this instrument, and acknowledged that he executed the same.

Notary Public

My Commission Expires 08.21.16

CATARINA N. GARCIA
Notary Public State of Utah
My Commission Expires on:
August 21, 2016
Comm. Number: 658177

WESTECH

Proposal For:
Town Branch Wet Weather Storage Facility
Lexington Municipal Utilities

Equipment:
11252 Vertical Mounted Mechanical Screen

Engineer:
GRW

Represented By:
Katie Avera
Eco-Tech, Inc
kavera@eco-tech.net
606-682-0887 – Cell

Furnished By:
WesTech Engineering, Inc.
Salt Lake City, Utah 84115
Contact: Steve Rioux
Direct: 801.290.6449
Phone: 801.265.1000
Fax: 801.265.1080

WesTech Proposal: 1360606
Thursday, September 18, 2014

Conformance Set

WESTECH

REFERENCE ENGINEER'S SPECIFICATION

SECTION: 11252 – Vertical Mounted Mechanical Screen
ADDENDA: None

ITEM: "A" - One (1) CleanFlo™ ROMAG Deflection Screen Model RSW 6x8/4

BASIS OF DESIGN (EACH)

Application:	Combined Sewer Overflow
Screen Mount:	Vertical
Max Design Flow:	57 MGD
Screen Opening:	4 mm

EACH UNIT FURNISHED COMPLETE BY WESTECH WITH THE FOLLOWING COMPONENTS:

MECHANICAL FINE SCREEN (EACH)

- Vertically mounted with control weir.
- Screen consisting of:
    1. Support frame.
    2. Vertically mounted screening area, composed of 4mm pre-stressed bars.
    3. Cleaning carriage assembly including hydraulic cylinder and piston, slide bearings and cleaning tines
- Overflow cover mounted to protect downstream side of screen and direct overflow beyond screen.
- Four (4) 48-inch long hydraulic synthetic rubber hose pig tails; two (2) mounted at screen, two (2) mounted at hydraulic power pack. JIC swivel fittings from stainless steel. *(Interconnecting hydraulic tubing between screen, and power pack is to be provided by the installing contractor).*

• Screen frame:	304L stainless steel
• Screen bars:	304L stainless steel
• Traveling cleaning carriage:	304L stainless steel
• Cleaning tines:	UHMW PE
• End cleaning Tines:	Bronze alloy
• Hydraulic cylinder:	Stainless steel, piston chrome plate
• Hydraulic power pack:	Painted carbon steel
• Support Struts:	304L stainless steel

HYDRAULIC POWER PACK (EACH)

- One (1) hydraulic power pack. The power pack shall contain the following:
    1. Fixed displacement hydraulic gear pump.
    2. Replaceable suction and oil filters.
    3. 10 gallon oil reservoir.
    4. Pressure limiting/relief valve.
    5. 0-3000 psi pressure gauge.
    6. Pressure transducer with 4-20mA output.
    7. Directional solenoid valve, NEMA 4.
    8. Filler breather cap with strainer.
    9. Oil level and temperature switch, NEMA 4.
    10. Air/oil return line heat exchanger.

Conformance Set

WESTECH

REFERENCE ENGINEER'S SPECIFICATION

SECTION: **11252 – Vertical Mounted Mechanical Screen**
ADDENDA: **None**

ITEM: "A" - One (1) CleanFlo™ ROMAG Deflection Screen Model RSW 6x8/4

BASIS OF DESIGN (EACH)

Application:	Combined Sewer Overflow
Screen Mount:	Vertical
Max Design Flow:	57 MGD
Screen Opening:	4 mm

EACH UNIT FURNISHED COMPLETE BY WESTECH WITH THE FOLLOWING COMPONENTS:

MECHANICAL FINE SCREEN (EACH)

- Vertically mounted with control weir.
- Screen consisting of:
    1. Support frame.
    2. Vertically mounted screening area, composed of 4mm pre-stressed bars.
    3. Cleaning carriage assembly including hydraulic cylinder and piston, slide bearings and cleaning tines
- Overflow cover mounted to protect downstream side of screen and direct overflow beyond screen.
- Four (4) 48-inch long hydraulic synthetic rubber hose pig tails; two (2) mounted at screen, two (2) mounted at hydraulic power pack. JIC swivel fittings from stainless steel. *(Interconnecting hydraulic tubing between screen, and power pack is to be provided by the installing contractor).*

• Screen frame:	304L stainless steel
• Screen bars:	304L stainless steel
• Traveling cleaning carriage:	304L stainless steel
• Cleaning tines:	UHMW PE
• End cleaning Tines:	Bronze alloy
• Hydraulic cylinder:	Stainless steel, piston chrome plate
• Hydraulic power pack:	Painted carbon steel
• Support Struts:	304L stainless steel

HYDRAULIC POWER PACK (EACH)

- One (1) hydraulic power pack. The power pack shall contain the following:
    1. Fixed displacement hydraulic gear pump.
    2. Replaceable suction and oil filters.
    3. 10 gallon oil reservoir.
    4. Pressure limiting/relief valve.
    5. 0-3000 psi pressure gauge.
    6. Pressure transducer with 4-20mA output.
    7. Directional solenoid valve, NEMA 4.
    8. Filler breather cap with strainer.
    9. Oil level and temperature switch, NEMA 4.
    10. Air/oil return line heat exchanger.

Conformance Set

11. Sight level/temperature gauge.
12. Reservoir drain valve.

- One (1) 5HP, 1800 rpm, TEFC severe duty motor suitable for 230/460/3/60 electrical supply.
- Hydraulic fluid for the Hydraulic Power Pack, 3x5 gal pails.

HARDWARE (EACH)
- Assembly fasteners from type 304 stainless steel.
- Anchor rods from type 304 stainless steel.

CONTROLS AND ELECTRICAL DEVICES (EACH)
- One (1) NEMA 12 painted steel wall mount main control panel suitable for 480/3/60 electrical supply. Control panel shall contain the following devices for operation of the screen unit:
  1. Main circuit breaker disconnect with through door interlock handle.
  2. Step down control transformer.
  3. TVSS – 120 vac.
  4. Branch circuit protection.
  5. Hydraulic pack motor starter – NEMA 1.
  6. Emergency stop pushbutton.
  7. Hour meter for screen motor.
  8. Control power and run indicating lights.
  9. Oil Temperature, low oil level, carriage reduced/blocked fault lights
  10. Loss of pressure fault light.
  11. High screen level fault light.
  12. Alarm light indicating overcurrent and starter overload.
  13. Alarm reset pushbutton.
  14. Allen-Bradley PLC – CompactLogix.
  15. Allen-Bradley Operator Interface – PanelView C400.
  16. Ethernet Switch, unmanaged
  17. Panel heater with thermostat.
  18. Run and alarm auxiliary contacts & via Ethernet communication.
  19. UL Label.

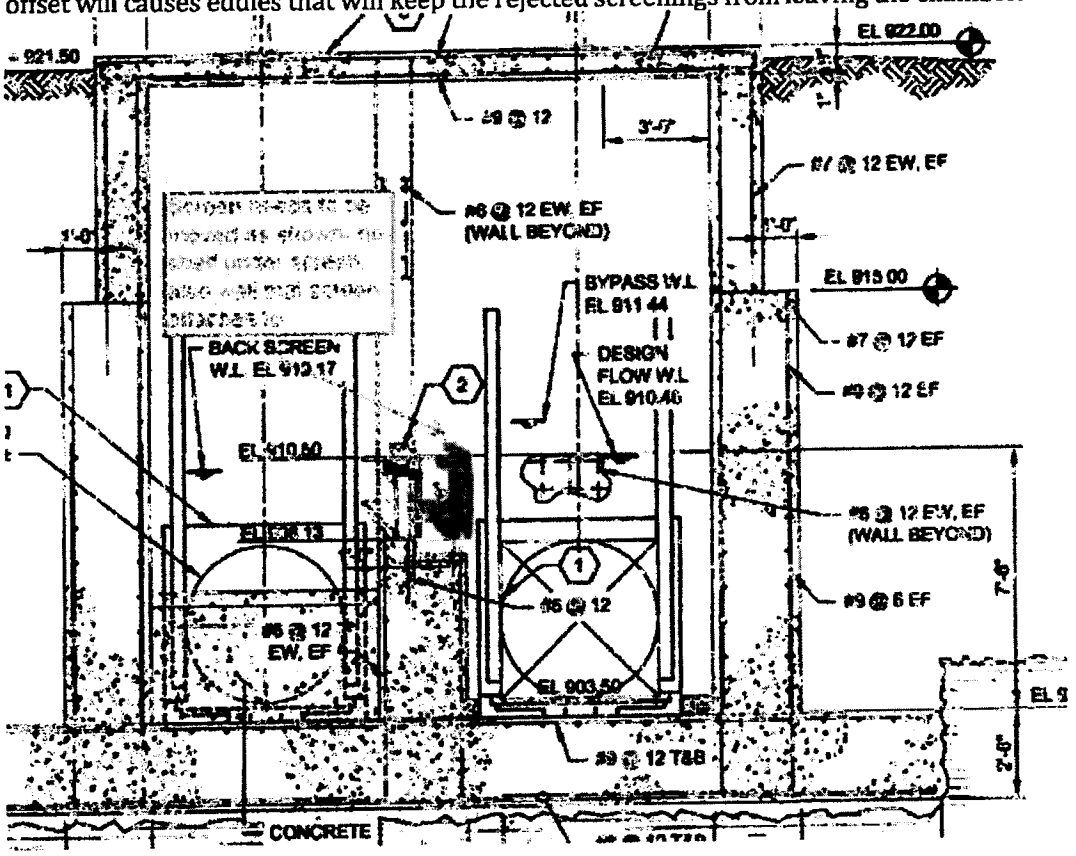
- One (1) Milltronics HydroRanger 200 ultrasonic level controller supplied in a windowed NEMA 4X polycarbonate enclosure including handheld programmer for mounting near the main control panel.
- One (1) Milltronics ultrasonic level transducer with type 316 stainless steel mounting bracket and integral 10m cable. Suitable for installation in a Class 1, Division 1. Group C and D location.

SPARE PARTS (TOTAL)
- Two (2) cleaning tine sections (standard).
- Two (2) cleaning tine section (end).
- Two (2) replacement oil filters.

FIELD SERVICE (TOTAL)
- One (1) trip and one (1) day for concrete inspection prior to equipment installation.
- Two (2) trips and three (3) days for equipment installation inspection, start up, and instruction of plant personnel.

CLARIFICATIONS/COMMENTS

- Unit anchorage designed around RedHead A7 adhesive system. Adhesive and applicator by others.
- The concrete weir that the screen will be mounted to needs to be level and horizontal with the perpendicular side walls.
- Plan Sheet I-3-102: The PID drawing used depicts the bending weir PID which needs hydraulic hoses for the cylinders on the weir and the flushing gate. The fixed weir Romag Screen specified only needs lines for the cleaning carriage cylinder, so only 2 hydraulic lines are needed.
- Plan Sheet I-3-102: The fixed weir specified only needs 1 transducer, as correctly noted in the specification.
- Plan Sheet C-3-101: The screen needs to be moved as I have shown below (no offset) and cannot have a shelf under it. As shown screening will accumulate below the screen and the offset will causes eddies that will keep the rejected screenings from leaving the chamber.



OPTIONAL ITEMS

- None.

WESTECH

NOTE: ANY ITEM NOT LISTED ABOVE TO BE FURNISHED BY OTHERS:

ITEMS NOT BY WESTECH: Electrical wiring, conduit or electrical equipment, piping, valves, or fittings, shimming material, lubricating oil or grease, shop or field painting, field welding, erection, detail shop fabrication drawings, performance testing, unloading, storage, concrete work, hoist or lifting apparatus, grating, platforms, stairs, handrailing, or field service (except as specifically noted).

This proposal section has been reviewed for accuracy and is approved for issue:
By: Stephen Rioux Date: September 18, 2014

WESTECH

PRICING

SECTION	ITEM	EQUIPMENT	PRICE (U.S.)
11252	"A"	(1) CleanFlo™ ROMAG Deflection Screen RSW 6x8/4	$290,000
		Estimated Sales Tax	$ 17,400
		Total:	$307,400

Sales Tax: Taxes are included in WesTech's proposal; however, WesTech is not registered to collect taxes in the state of Kentucky. Contractor will need to pay the required tax at the current rate to the Taxing Authority directly.

Please ensure to reference this quotation number and date on your purchase order. Please make order to: WesTech Engineering, Inc. 3665 S. West Temple Salt Lake City, Utah 84115 Attn: Catarina N. Garcia cgarcia@westech-inc.com.

We appreciate the opportunity to offer our equipment. Upon award of an order, we assure you of our continued interest and service. At WesTech we realize that only the best possible equipment will be accepted, and we trust we will exceed your expectations.

This proposal, including all terms and conditions contained herein, shall become part of any resulting contract or purchase order. Changes to any terms and conditions, including but not limited to submittal and shipment days, payment terms, and escalation clause shall be negotiated at order placement, otherwise the proposal terms and conditions contained herein shall apply.

The above mentioned equipment was designed according to the information which we received. The dimensions may vary slightly depending upon the plant's actual design parameters. Assumed values may have been used, therefore, all information shall be verified by the engineer.

Unless otherwise indicated, prices listed are for equipment only. All optional items will be offered with the purchase of the scoped equipment only. No optional items will be sold separately.

Terms: Terms for equipment are 15 percent payment of the purchase price with submittal drawings, 35 percent upon release for fabrication, and 50 percent net **30 days** from shipment. Retentions are not allowed.

Freight: Prices quoted are **F.O.B. shipping point** with freight allowed to a readily accessible location nearest to jobsite. All claims for damage or loss in shipment shall be initiated by purchaser.

Submittals: Submittals will be made approximately **6 to 8 weeks** after purchase order is received in our office.

Shipment: Estimated shipment time is **18 to 20 weeks** after approved submittal drawings are received in our office.

Field Service: Prices do not include field service unless noted in equipment description. Additional field service is available at $960.00 per day plus expenses.

Paint: If your equipment has paint included in the price, please take note of the following. Primer paints are designed to provide only a minimal protection from the time of application (usually for a period not to exceed 30 days). Therefore, it is imperative that the finish coat be applied within 30 days of shipment on all shop primed surfaces. Without the protection of the final coatings, primer degradation may occur after this period, which in turn may require renewed surface preparation and coating. If it is impractical or impossible to coat primed surfaces within the suggested time frame, WesTech strongly recommends the supply of bare metal, with surface preparation and coating performed in the field. All field surface preparation, field paint, touch-up and repair to shop painted surfaces are not by WesTech.

One Year Warranty

WesTech equipment is backed by WesTech's reputation as a quality manufacturer, and by many years of experience in the design of reliable equipment.

Equipment manufactured or sold by WesTech Engineering, Inc., once paid for in full, is backed by the following warranty:

For the benefit of the original user, WesTech warrants all new equipment manufactured by WesTech Engineering, Inc. to be free from defects in material and workmanship, and will replace or repair, F.O.B. its factories or other location designated by it, any part or parts returned to it which WesTech's examination shall show to have failed under normal use and service by the original user within one (1) year following initial start-up, or eighteen (18) months from shipment to the purchaser, whichever occurs first.

Such repair or replacement shall be free of charge for all items except for those items such as resin, filter media and the like that are consumable and normally replaced during maintenance, with respect to which, repair or replacement shall be subject to a pro-rata charge based upon WesTech's estimate of the percentage of normal service life realized from the part. WesTech's obligation under this warranty is conditioned upon its receiving prompt notice of claimed defects, which shall in no event be later than thirty (30) days following expiration of the warranty period, and is limited to repair or replacement as aforesaid.

This warranty is expressly made by WesTech and accepted by purchaser in lieu of all other warranties, including warranties of merchantability and fitness for particular purpose, whether written, oral, express, implied, or statutory. WesTech neither assumes nor authorizes any other person to assume for it any other liability with respect to its equipment. WesTech shall not be liable for normal wear and tear, corrosion, or any contingent, incidental, or consequential damage or expense due to partial or complete inoperability of its equipment for any reason whatsoever.

This warranty shall not apply to equipment or parts thereof which have been altered or repaired outside of a WesTech factory, or damaged by improper installation, application, or maintenance, or subjected to misuse, abuse, neglect, accident, or incomplete adherence to all manufacturer's requirements, including, but not limited to, Operations & Maintenance Manual guidelines & procedures.

This warranty applies only to equipment made or sold by WesTech Engineering, Inc.

WesTech Engineering, Inc. makes no warranty with respect to parts, accessories, or components purchased by the customer from others. The warranties which apply to such items are those offered by their respective manufacturers.

QF-00-032E

Rev. 2005AUG18

Terms and Conditions appearing in any order based on this proposal which are inconsistent herewith shall not be binding on WesTech Engineering Inc. The sale and purchase of equipment described herein shall be governed exclusively by the foregoing proposal and the following provisions:

1. SPECIFICATIONS: WesTech Engineering Inc. is furnishing its standard equipment as outlined in the proposal and as will be covered by final approved drawings. The equipment may not be in strict compliance with the Engineer's/Owner's plans, specifications, or addenda as there may be deviations. The equipment will, however, meet the general intention of the mechanical specifications of these documents.

2. ITEMS INCLUDED: This proposal includes only the equipment specified herein and does not include erection, installation, accessories, nor associated materials such as controls, piping, etc., unless specifically listed.

3. PARTIES TO CONTRACT: WesTech Engineering Inc. is not a party to or bound by the terms of any contract between WesTech Engineering Inc.'s customer and any other party. WesTech Engineering Inc.'s undertakings are limited to those defined in the contract between WesTech Engineering Inc. and its direct customers.

4. PRICE AND DELIVERY: All selling prices quoted are subject to change without notice after 30 days from the date of this proposal unless specified otherwise. Unless otherwise stated, all prices are F.O.B. WesTech Engineering Inc. or its supplier's shipping points. All claims for damage, delay or shortage arising from such equipment shall be made by Purchaser directly against the carrier. When shipments are quoted F.O.B. job site or other designation, Purchaser shall inspect the equipment shipped, notifying WesTech Engineering Inc. of any damage or shortage within forty-eight hours of receipt, and failure to so notify WesTech Engineering Inc. shall constitute acceptance by Purchaser, relieving WesTech Engineering Inc. of any liability for shipping damages or shortages.

5. PAYMENTS: All invoices are net 30 days. Delinquencies are subject to a 1.5 percent service charge per month or the maximum permitted by law, whichever is less on all past due accounts. Pro rata payments are due as shipments are made. If shipments are delayed by the Purchaser, invoices shall be sent on the date when WesTech Engineering Inc. is prepared to make shipment and payment shall become due under standard invoicing terms. If the work to be performed hereunder is delayed by the Purchaser, payments shall be based on the purchase price and percentage of completion. Products held for the Purchaser shall be at the risk and expense of the Purchaser. Unless specifically stated otherwise, prices quoted are for equipment only. These terms are independent of and not contingent upon the time and manner in which the Purchaser receives payment from the owner.

6. PAYMENT TERMS: Credit is subject to acceptance by WesTech Engineering Inc.'s Credit Department. If the financial condition of the Purchaser at any time is such as to give WesTech Engineering Inc., in its judgment, doubt concerning the Purchaser's ability to pay, WesTech Engineering Inc. may require full or partial payment in advance or may suspend any further deliveries or continuance of the work to be performed by the WesTech Engineering Inc. until such payment has been received.

7. ESCALATION: If shipment is, for any reason, deferred by the Purchaser beyond the normal shipment date, or if material price increases are greater than 5% from proposal date to material procurement date, stated prices set forth herein are subject to escalation. The escalation shall be based upon increases in labor and material and other costs to WesTech Engineering Inc. that occur in the time period between quotation and shipment by WesTech Engineering Inc. Purchaser agrees to this potential escalation regardless of contradicting terms in the contract, except when an agreed upon escalation adder is included in the price.

(a) The total quoted revised price is based upon changes in the indices published by the United States Department of Labor, Bureau of Labor Statistics. Labor will be related to the Average Hourly Earnings indices found in the Employment and Earnings publication. Material will be related to the Metal and Metal Products indices published in Wholesale Prices and Prices Indices.

(b) Price revision for items furnished to, and not manufactured by WesTech Engineering Inc., which exceed the above escalation calculation, will be passed along by WesTech Engineering Inc. to Purchaser based upon the actual increase in price to WesTech Engineering Inc. for the period from the date of quotation to the date of shipment by WesTech Engineering Inc. Any item that is so revised will be excluded from the index escalation calculations set forth in subparagraph (a) above.

8. APPROVAL: If approval of equipment submittals by Purchaser or others is required, a condition precedent to WesTech Engineering Inc. supplying any equipment shall be such complete approval.

9. INSTALLATION SUPERVISION: Prices quoted for equipment do not include installation supervision. WesTech Engineering Inc. recommends and will, upon request, make available, at WesTech Engineering Inc.'s then current rate, an experienced installation supervisor to act as the Purchaser's employee and agent to supervise installation of the equipment. Purchaser shall at its sole expense furnish all necessary labor equipment, and materials needed for installation.

Responsibility for proper operation of equipment, if not installed by WesTech Engineering Inc. or installed in accordance with WesTech Engineering Inc.'s instructions, and inspected and accepted in writing by WesTech Engineering Inc., rests entirely with Purchaser; and any work performed by WesTech Engineering Inc. personnel in making adjustment or changes must be paid for at WesTech Engineering Inc.'s then current per diem rates plus living and traveling expenses.

WesTech Engineering Inc. will supply the safety devices described in this proposal or shown in WesTech Engineering Inc.'s drawings furnished as part of this order but excepting these, WesTech Engineering Inc. shall not be required to supply or install any safety devices whether required by law or otherwise. The Purchaser hereby agrees to indemnify and hold harmless WesTech Engineering Inc. from any claims or losses arising due to alleged or actual insufficiency or inadequacy of the safety devices offered or supplied hereunder, whether specified by WesTech Engineering Inc. or Purchaser, and from any damage resulting from the use of the equipment supplied hereunder.

10. ACCEPTANCE OF PRODUCTS: Products will be deemed accepted without any claim by Purchaser unless written notice of non-acceptance is received by WesTech Engineering Inc. within 30 days of delivery if shipped F.O.B. point of shipment, or 48 hours of delivery if shipped F.O.B. point of destination. Such written notice shall not be considered received by WesTech Engineering Inc. unless it is accompanied by all freight bills for said shipment, with Purchaser's notations as to damages, shortages and conditions of equipment, containers, and seals. Non-accepted products are subject to the return policy stated below.

11. TAXES: Any federal, state, or local sales, use or other taxes applicable to this transaction, unless specifically included in the price, shall be for Purchaser's account.

12. TITLE: The equipment specified herein, and any replacements or substitutes therefore shall, regardless of the manner in which affixed to or used in connection with realty, remain the sole and personal property of WesTech Engineering Inc. until the full purchase price has been paid. Purchaser agrees to do all things necessary to protect and maintain WesTech Engineering Inc.'s title and interest in and to such equipment; and upon Purchaser's default, WesTech Engineering Inc. may retain as liquidated damages any and all partial payments made and shall be free to enter the premises where such equipment is located and remove the same as its property without prejudice to any further claims on account of damages or loss which WesTech Engineering Inc. may suffer from any cause.

13. INSURANCE: From date of shipment until the invoice is paid in full, Purchaser agrees to provide and maintain at its expense, but for WesTech Engineering Inc.'s benefit, adequate insurance including, but not limited to, builders risk insurance on the equipment against any loss of any nature whatsoever.

14. SHIPMENTS: Any shipment of delivery dates recited represent WesTech Engineering Inc.'s best estimate but no liability, direct or indirect, is assumed by WesTech Engineering Inc. for failure to ship or deliver on such dates.

WesTech Engineering Inc. shall have the right to make partial shipments; and invoices covering the same shall be due and payable by Purchaser in accordance with the payment terms thereof. If Purchaser defaults in any payment when due hereunder, WesTech Engineering Inc. may, without incurring any liability therefore to Purchaser or Purchaser's customers, declare all payments immediately due and payable with maximum legal interest thereon from due date of said payment, and at its option, stop all further work and shipments until all past due payments have been made, and/or require that any further deliveries be paid for prior to shipment.

If Purchaser requests postponements of shipments, the purchase price shall be due and payable upon notice from WesTech Engineering Inc. that the equipment is ready for shipment; and thereafter any storage or other charge WesTech Engineering Inc. incurs on account of the equipment shall be for the Purchaser's account.

If delivery is specified at a point other than WesTech Engineering Inc. or its supplier's shipping points, and delivery is postponed or prevented by strike, accident, embargo, or other cause beyond WesTech Engineering Inc.'s reasonable control and occurring at a location other than WesTech Engineering Inc. or its supplier's shipping points,

WesTech Engineering Inc. assumes no liability in delivery delay. If Purchaser refuses such delivery, WesTech Engineering Inc. may store the equipment at Purchaser's expense. For all purposes of this agreement such tender of delivery or storage shall constitute delivery.

15. WARRANTY: WESTECH ENGINEERING INC. WARRANTS EQUIPMENT IT SUPPLIES ONLY IN ACCORDANCE WITH THE WARRANTY EXPRESSED IN THE ATTACHED COPY OF "WESTECH WARRANTY" AGAINST DEFECTS IN WORKMANSHIP AND MATERIALS WHICH IS MADE A PART HEREOF. SUCH WARRANTY IN LIEU OF ALL OTHER WARRANTIES, INCLUDING WARRANTIES OF MERCHANTABILITY AND FITNESS FOR PARTICULAR PURPOSE, WHETHER WRITTEN, ORAL, EXPRESSED, IMPLIED OR STATUTORY, WESTECH ENGINEERING INC. SHALL NOT BE LIABLE ANY CONTINGENT, INCIDENTAL, OR CONSEQUENTIAL DAMAGES FOR ANY REASON WHATSOEVER.

16. PATENTS: WesTech Engineering Inc. agrees that it will, at its own expense, defend all suits or proceedings instituted against Purchaser and pay any award of damages assessed against it in such suits or proceedings, so far as the same are based on any claim that the said equipment or any part thereof constitutes an infringement of any apparatus patent of the United States issued at the date of this Agreement, provided WesTech Engineering Inc. is given prompt notice in writing of the institution or threatened institution of any suit or proceeding and is given full control of the defense, settlement, or compromise of any such action; and Purchaser agrees to give WesTech Engineering Inc. needed information, assistance, and authority to enable WesTech Engineering Inc. so to do. In the event said equipment is held or conceded to infringe such a patent, WesTech Engineering Inc. shall have the right at its sole option and expense to a) modify the equipment to be non-infringing, b) obtain for Purchaser the license to continue using said equipment, or c) accept return of the equipment and refund to the Purchaser the purchase price thereof less a reasonable charge for the use thereof. WesTech Engineering Inc. will reimburse Purchaser for actual out-of-pocket expenses, exclusive of legal fees, incurred in preparing such information and rendering such assistance at WesTech Engineering Inc.'s request. The foregoing states the entire liability of WesTech Engineering Inc., with respect to patent infringement; and except as otherwise agreed to in writing, WesTech Engineering Inc. assumes no responsibility for process patent infringement.

17. SURFACE PREPARATION AND PAINTING: If furnished, shop primer paint is intended to serve only as minimal protective finish. WesTech Engineering Inc. will not be responsible for the condition of primed or finish painted surfaces after equipment leaves its shops. Purchasers are invited to inspect paint in shops for proper preparation and application prior to shipment. WesTech Engineering Inc. assumes no responsibility for field surface preparation or touch-up of shipping damage to paint. Painting of fasteners and other touch-up to painted surfaces will be by Purchaser's painting contractor after mechanism installation.

Motors, gear motors, and other components not manufactured by WesTech Engineering Inc. will be painted with that manufacturer's standard paint system. It is WesTech Engineering Inc.'s intention to ship major steel components as soon as fabricated, often before drive, motors, and other manufactured components. Unless Purchaser can ensure that shop primed steel shall be field painted within thirty (30) days after arrival at the job site, WesTech Engineering Inc. encourages the Purchaser to order these components without primer.

WesTech Engineering Inc.'s prices are based on paints and surface preparations as outlined in the main body of this proposal. In the event that an alternate paint system is selected, WesTech Engineering Inc. requests that Purchaser's order advise of the paint selection. WesTech Engineering Inc. will then either adjust the price as may be necessary to comply or ship the material unpainted if compliance is not possible due to application problems or environmental controls.

18. CANCELLATION, SUSPENSION, OR DELAY: After acceptance by WesTech Engineering Inc., this proposal, or Purchaser's order based on this proposal, shall be a firm agreement and is not subject to cancellation, suspension, or delay except upon payment by Purchaser of appropriate charges which shall include all costs incurred by WesTech Engineering Inc. to date of cancellation, suspension, or delay plus a reasonable profit. Additionally, all charges related to storage and/or resumption of work, at WesTech Engineering Inc.'s plant or elsewhere, shall be for Purchaser's sole account; and all risks incidental to storage shall be assumed by Purchaser.

19. RETURN OF PRODUCTS: No products may be returned to WesTech Engineering Inc. without WesTech Engineering Inc.'s prior written permission. Said permission may be withheld by WesTech Engineering Inc. at its sole discretion.

20. BACKCHARGES: WesTech Engineering Inc. will not approve or accept backcharges for labor, materials, or other costs incurred by Purchaser or others in modification, adjustment, service, or repair of WesTech Engineering Inc.-furnished materials unless such back charge has been authorized in advance in writing by a WesTech Engineering Inc. employee, by a WesTech Engineering Inc. purchase order, or work requisition signed by WesTech Engineering Inc.

21. INDEMNIFICATION: Purchaser agrees to indemnify WesTech Engineering Inc. from all costs incurred, including but not limited to court costs and reasonable attorney fees, from enforcing any provisions of this contract, including but not limited to breach of contract or costs incurred in collecting monies owed on this contract.

22. ENTIRE AGREEMENT: This proposal expresses the entire agreement between the parties hereto superseding any prior understandings, and is not subject to modification except by a writing signed by an authorized officer of each party.

23. MOTORS AND MOTOR DRIVES: In order to avoid shipment delays of WesTech Engineering Inc. equipment, the motor drives may be sent directly to the job site for installation by the equipment installer. Minor fit-up may be required.

24. EXTENDED STORAGE: Extended storage instructions will be part of information provided to shipment. If equipment installation and start-up is delayed more than 30 days, the provisions of the storage instructions must be followed to keep WARRANTY in force.

25. LIABILITY: Professional liability insurance, including but not limited to, errors and omissions insurance, is not included. In any event, liability for errors and omissions shall be limited to the lesser of $100,000USD or the value of the particular piece of equipment (not the value of the entire order) supplied by WesTech Engineering Inc. against which a claim is sought.

26. ARBITRATION NEGOTIATION: Any controversy or claim arising out of or relating to the performance of any contract resulting from this proposal or contract issued, or the breach thereof, shall be settled by arbitration in accordance with the Construction Industry Arbitration Rules of the American Arbitration Association, and judgment upon the award rendered by the arbitrator(s) may be entered to any court having jurisdiction.

ACCEPTED BY PURCHASER

Customer Name: _____

Customer Address: _____

_____

_____

Contact Name: _____

Contact Phone: _____

Contact Email: _____

Signature: _____

Printed Name: _____

Title: _____

Date: _____