SECTION 9 PROCESS SYSTEMS

Subsection 1 through 4
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SECTION 9 PROCESS SYSTEMS
SUBSECTION 1 MECHANICAL SYSTEMS

1.0 MECHANICAL EQUIPMENT, VALVES AND DEVICES

1.1 This section provides requirements and specifications pertaining to the following mechanical equipment, devices, valves and sensors:

- Gate valves
- Check valves
- Ball valves and Corp Stops
- Magnetic Flow Meter
- Pressure Transmitter
- Level Transmitter

1.2 REFERENCES . The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

- ASTM A106 (2014) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
- ASTM A153 (2009) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
- ASTM A536 Standard Specification for Ductile Iron

1.3 SUBMITTALS.

- Shop Drawings Installation;
- Product Data Material and Equipment Framed Instructions
- Test Reports
- Operation and Maintenance Data Closeout Activities

1.4 DELIVERY, STORAGE, AND HANDLING. Protect all equipment delivered and placed in storage from the weather, humidity and temperature variation, dirt and dust, or other contaminants. Instruments, sensors, electromechanical equipment or devices requiring calibration shall be stored off-site and brought to the project location immediately prior to installation.

1.5 MAINTENANCE, EXTRA MATERIALS AND TOOLS

1.5.1 Auxiliary Equipment and Spare Parts. Furnish auxiliary equipment and spare parts as follows:

- One (1) spare flow rate indicator for each machine.
- One (1) flexible tank connection for each machine.
- Three (3) each of all special gaskets to fit all joints and unions.
- One (1) set of all necessary hose clamps to suit all hose connections;
- One (1) each check valve flapper for each size of valve;
- Other spares routinely provided and recommended by the manufacturer of each device, system or subsystem.

1.5.2 Special Tools. For each type of equipment furnished provide special tools necessary for adjustment, operation, maintenance and disassembly.

2.0 MECHANICAL COMPONENTS

2.1 GENERAL REQUIREMENTS

2.1.1 Standard Products. Provide material and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of the products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Equipment shall be supported by a service organization that is, in the opinion of the Engineer, reasonably convenient to the site.

2.1.2 Nameplates. Major equipment items shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the item of equipment.

2.1.3 Miscellaneous Supports. Bolts, nuts, anchors, washers, and all other types of supports necessary for the installation of the equipment shall be 316 stainless steel, galvanized steel, or cadmium plated steel.

2.1.4 Submittal Data. Submit a complete list of equipment and material, including manufacturer's descriptive data and technical literature, performance charts and curves, catalog cuts, and installation instructions. Spare parts data for each different item of material and equipment specified, after approval of the detail drawings and not later than 30 days prior to the date of beneficial occupancy. Include in the data a complete list of parts and supplies, with current unit prices and source of supply, and a list of the parts recommended by the manufacturer to be replaced after one year of service.

2.2 RESILIENT SEATED GATE VALVES. Where called for on the plans. provide AMERICAN Flow Control Series 2500 Ductile Iron Resilient Seated Gate Valves rated for 200 psig working pressure which conform with ANSI/AWWA C515 for use in potable water systems.

2.2.1 Materials. Manufacture from ductile iron meeting or exceeding ASTM A536.

- Valves shall have a ductile iron wedge encapsulated with EPDM rubber with male type guides and polymer guide covers. Valves to be coated with NSF-approved fusion-bonded epoxy on all internal and external ferrous surfaces complying with ANSI/AWWA C550.

- Body to bonnet bolts shall be 304 stainless steel with hexagonal heads conforming to ANSI B18.2.1.

- Valves within vaults shall be provided with operating wheel; in-ground valves shall be provided with 2-inch AWWA operating nut and valve box.

- All gaskets shall be pressure energized O-Rings. Stem shall be sealed by three 3 each O-rings of which the top rings are replaceable with the valve fully open and under pressure.

2.2.2 Series and Model. Furnish AMERICAN Flow Control Series 2500 gate valves.

- Exterior. 24-inch gate valves and smaller may be direct bury. If the anticipated depth and location requires it, the valve shall be furnished with a 90 degree bevel operator.

- Interior. Provide gate valves in the process piping as required on the plans. These valves must be non-rising stem unless approved by the Engineer.

2.2.3 When valves are received, unload carefully and protect stored valves from the elements and from undue damage in handling. At the time of installation

- Check bonnet bolting for tightness and visually confirm that the valve turns freely from the closed position to the full open position prior to placement in the pipage.

- Support valve by direct connection of the valve to the valve vault floor by concrete pedestal or permanent stainless steel shims so that strains are not exerted on the valve body or connected piping.

- Do not insert the valve as a final step in the piping. Ensure the piping is properly lined up and spaced so that the bolting of the valve in the line is not used to correct any errors in piping alignment or spacing. Position and orient valve to ensure that it can be removed in its entirety for maintenance or replacement.

2.3 SWING CHECK VALVES. When called for on the plans, provide APCO DeZurik Brand check valves rated for 200 psig working pressure which conform to AWWA C508:

2.3.1 Materials. Manufacture valve body and integrally cast-on flanges from ductile iron meeting or exceeding ASTM A536.

- Valves to be coated with NSF-approved fusion-bonded epoxy on all internal and external ferrous surfaces. The flapper disc shall be ductile iron disc fully encapsulated with EPDM rubber. Exposed metallic rings are not allowed.

- Body to bonnet fasteners to be Type 304 stainless steel.

2.3.2 Series and Model. There are two types of check valves to be employed in the project.

- Exterior. Check valves of the required diameters to be installed in the process lines as shown on the drawings. This valve may be direct bury. The valve shall be APCO Series 100 Model 124, 125#150 Class.

- Interior. Provide check valves in the process or discharge piping of the facility. The valves shall be APCO Series 100 Model 110, 125#150 Class.

2.3.3 Operation. Disc shall be the only allowable moving part. No O-Rings, pivot pins or other bearings are allowed. Disc must be reversible such that either side will seal equally. Disc travel to closure shall not be more than 35°F and shall seal with no leakage at pressures above 4 psig.

2.3.4 Installation. When valves are received, unload carefully and stored with disc in closed position. Protect stored valves from the elements and from undue damage in handling.

- Check bonnet bolting for tightness and make sure that the disc swings freely from the closed position to full stop in the open position

- Check the direction of flow in the pipeline and make sure that the arrow cast on the side of the valve body agrees with the direction of flow so that the disc will swing open with flow through the valve;

- Support valve by direct connection of the valve to the valve vault floor by concrete pedestal or permanent stainless steel shims so that strains are not exerted on the check valve body.

- Do not insert the valve as a final step in the piping. Ensure the piping is properly lined up and spaced so that the bolting of the valve in the line is not used to correct any errors in piping alignment or spacing. Orient valve to ensure that it can be removed in its entirety for maintenance or replacement.

2.4 BALL VALVES AND CORP STOPS.

2.4.1 Corps Stops. Provide and install 1-inch Corporation Stops on discharge manifold piping, on the discharge side of new check valves, and at other locations as shown on the drawing. For retrofit applications, place the corp stops in the spool pieces between the existing and new pipage.

- Corp Stops shall be Ford Ballcorp Brand Series F1700 1-inch male iron pipe thread inlet and female iron pipe thread outlet, Ford F1700-4-NL, with 1-inch brass corp stop plugs with square wrench head.

- Install in the vertical position. For exterior line installations, install with valve box and cover.

2.4.2 Ball Valves. Provide and install a single 1-inch F-NPT x F-NPT full port 200 psi forged brass ball valve on the pump discharge manifolds or as shown on the drawings.

2.4 ELECTROMAGNETIC FLOW METER. Install electromagnetic flows meters in sewage piping and where shown on the drawings. Provide McCrometer Ultra Mag Mx08-W, with velocity-sensing electromagnetic type flanged tube meter rated for 150 psig working pressure in conformance with ANSI/AWWA C508 for use in potable water systems.

2.4.1 Materials. Fabricate meter tube sensor of stainless steel pipe with a constant nominal inside diameter with no flow obstructions with 150 lb. AWWA Class “D” flat face stainless steel flanges. The internal and external of the meter tube shall be blasted and lined with an NSF approved fusion bonded epoxy liner.

2.4.2 Meter. The meter shall have the capability of measuring velocity in the discharge pipe in the range of 0.2 to 32 feet per second to an accuracy of plus or minus 0.5% of actual flow. Size the meter for the ultimate anticipated range of flows.

2.4.3 Sensor Assembly. Mag shield shall be welded to the tube providing a completely sealed environment for all coils, electrode connections and wiring harness capable of NEMA 6P/IP68 operation. Electrodes and grounding rings shall be Type 316 stainless steel.

2.4.4 Signal Converter. The L-Series signal converter is the reporting, input and output control device for the sensor. The converter allows the measurements, functional programming, control of the sensor and data recording to be communicated through the display and hard wired inputs/outputs.

- Signal converter shall be pulsed DC coil excitation type with auto zeroing. The converter shall indicate direction of flow and provide a flow rate indication and a totalization of flow volume for both forward and reverse directions. Both forward and reverse totalizers shall be electronically resettable.

- The flow meter signal converter shall be microprocessor based with a keypad for instrument set up and LCD displays for totalized flow, flow rate, flow rate units, and velocity. The converter shall power the flow sensing element and provide galvanically isolated dual 4-20mA outputs. It shall be possible, in the test mode, to easily set the converter outputs to any desired value within the range. The 4-20mA scaling, time constants, pipe size, flow proportional output, flow units and test mode values shall be easily set via the keypad and display.

- The converter assembly shall have a digital indicator having a range of 0 to 2000 gpm equipped with a 9-digit totalizer reading in units of gallons per minute accurate to within five-tenths percent (0.5%) of actual flow within the range of two-tenths feet per second (0.2') to twenty five feet (25') per second.

2.4.5 Testing. Calibration and volumetric testing will be completed at the manufacturer's location prior to shipment. The complete meter assembly and signal converter must be wet accuracy tested and calibrated. The test facility must be traceable to an accuracy of ±0.15% with the National Institute of Standards and Technology. Furnish a copy of the certified accuracy test record.

2.4.6 Installation. When meters are received, unload carefully, store in a dry and secure location and install as soon as possible thereafter. Protect stored valves from the elements and from undue damage in handling. At the time of installation

- Support the meter by direct connection of the meter to the valve vault floor by concrete pedestal or permanent stainless steel shims so that strains are not induced on the meter body or flanges.

- Do not insert the meter as a final step in the piping. Ensure the piping is properly lined up and spaced so that the bolting of the meter in the line is not used to correct any errors in piping alignment or spacing. Locate and orient meter to ensure that it can be removed in its entirety for maintenance or replacement.

- The signal converter shall be remotely mounted up in the station panel above the valve vault apart from the sensor pipe assembly, and shall be supplied in a sealed IP67 rated enclosure. Four separate fully programmable alarm outputs shall be provided to indicate, as a minimum, empty pipe, forward/reverse polarity (normally open/close), analog over-range, fault conditions, high/low flow rates, percent of range and pulse cutoff. The converter shall periodically perform self-diagnostics and display resulting error messages. All set up, data and totalizer values may be protected by a password.

2.4.7 Commissioning. Supplier must have flow calibration laboratories, equipment, and personnel to perform testing and certify calibration. Personnel shall also provide on-site installation oversight and training of City personnel as required; and thereafter ensure meters are supported and maintained throughout the guarantee period.

2.5. PRESSURE TRANSMITTER. Provide and install a line pressure transmitter in the discharge manifold of all pump station or line piping as shown on the plans in order to measure and transmit real-time pressure in the line, with the following features:

2.5.1 Materials. Process wetted materials shall be 316 stainless steel. Body material shall be 316 stainless steel. Process connections shall be ½-inch NPT.

2.5.2 Operation. Measures 0 to 250 psi, continuously adjustable span, zero and dampening adjustments, integral indicator scaled in engineering units, Solid state circuitry with 4-20 mA output. Accuracy shall be not be more than 1% of full design range.

2.5.3 Installation. Install using stainless steel tap or equivalent corp stop centered atop the manifold discharge line of the lift station between pumps 1 and 2.

2.5.4 Model and Series. Pressure transmitter shall be Rosemount Model 3051P, or approved equal.

2.6 LEVEL TRANSMITTER. Provide and install a Submersible Level Transmitter in the wet well of the new lift station operating by measuring hydrostatic pressure via a sensing element so as to independently sense the fluid level apart from the mercury float switch system provided by the pump manufacturer.

2.6.1 Materials. The cable containing the sensing wires shall be a factory assembled and sealed nominal 1/4-inch OD flexible polypropylene covered cable, have spacers every four feet and have a flexible PVC boot at the top. The cable length shall be of sufficient length to run from the wet well to the junction box atop the wet well or extend to the Control Building with slack for internal routing.

2.6.2 Operation. The transmitter shall be a solid state unit with 4-20 mA output with a maximum load resistance of 650 ohms at 24 VDC. It shall have span-adjustable switches, non-interacting zero, and span fine tuning adjustments, transient (lightning/surge) protection and a selectable time delay for response output. The well level measurement system shall be powered by an external 24 VDC power supply.

2.6.3 Installation. The transmitter shall be mounted at the top of the wet well in a weather-proof conduit housing with ¾ NPT connections for the sensing wire/flexible boot and a ¾ NPT connection for the 4-20 mA signal cable.

2.6.4 Model and Series. Provide Drexelbrook Model 575P Level Transmitter or Sigma Controls, Inc. equivalent liquid level pressure probe, or approved equal.

SECTION 9 PROCESS SYSTEMS
SUBSECTION 2 ELECTRICAL SYSTEMS

1.0 BASIC ELECTRICAL MATERIALS AND METHODS

1.1 THE REQUIREMENT. The CONTRACTOR shall furnish all tools, equipment, materials, and supplies and shall perform all labor required to complete the electrical work as indicated on the Drawings and specified herein. This section covers the work necessary to furnish and install, complete, the materials specified hereinafter.

1.2 RELATED WORK SPECIFIED ELSEWHERE.

1.2.1 The work of the following Sections and Divisions applies to the work of this Section. Other Sections and Divisions, not referenced below, shall apply to the extent required for proper performance of this work.

- All Electrical Division specifications.
- Work Specified Under Other Divisions:
- All concrete work required for encasement, installation, or construction of electrical duct bank and generator pads shall be 4000-psi concrete.
- Ensure excavated trenches are dry, clean, neatly squared and free of slough. Consolidation of encasement concrete around duct banks shall be by hand puddling, and/or no mechanical vibration.
- A workability admixture shall be used in encasement concrete, which shall be a hydroxylated carboxylic acid type in liquid form. Admixtures containing calcium chloride shall not be used.
- Concrete for encasement of conduit or duct banks shall contain an integral red-oxide coloring pigment in the proportion of 8 pounds per cubic yard of concrete.
- Components for heating and ventilation systems, including conductors for control wiring, unless specifically shown on Electrical Drawings.

1.2.2 Materials and equipment furnished and installed under other Divisions with raceway and electrical conductors furnished, installed and connected under these or special specifications.

1.3 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

1.3.1 All work specified herein shall conform to or exceed the applicable requirements of the referenced portions of the following publications to the extent that the provisions thereof are not in conflict with other provisions of these specifications.

- FS W-C-596E/GEN(1) Connector, Plug, Receptacle and Cable Outlet, Electrical Power.
- FS W-S-896E/GEN(1) Switches, Toggle (Toggle and Lode), Flush Mounted (ac).

- FS WW-C-581E Conduit, Metal, Rigid, And Intermediate; And Coupling, Elbow, and Nipple, Electrical Conduit: Steel, Zinc Coated.

- ANSI B16.5 Pipe Flanges and Flanged Fittings, Steel, Nickel Alloy, and Other Special Alloys.

- ANSI C80.1 Rigid Steel Conduit, Zinc Coated, specification for.

- ANSI Z55.1 Gray Finishes for Industrial Apparatus and Equipment.

- ANSI/UL 467 Grounding and Bonding Equipment, Safety Standard For.

- NEMA WD-1-1.10 General Requirements for Wiring Devices

- NEMA AB-1 Molded Case Circuit Breakers.

- NEMA PB-1 Panelboards

- NEMA KS-1 Enclosed Switches.

- UL 943Ground Fault Circuit Interrupters

1.3.2 All equipment furnished by the CONTRACTOR shall be listed by and shall bear the label of Underwriters' Laboratories, Incorporated, (UL) or of an independent testing laboratory acceptable to the ENGINEER.

1.3.3 The construction and installation of all electrical equipment and materials shall comply with all applicable provisions of the NEC and applicable local codes and regulations.

1.4 CONTRACTOR SUBMITTALS. Submittals shall be made in accordance with the requirements of Section 01001s.

2.0 MATERIALS.

2.1 SERVICE ENTRANCE

2.1.1 Provide labor and furnish equipment as required by the electric utility which will provide service to the facility or station. All such materials and work shall meet the requirements of the utility company.

2.1.2 Provide temporary service for construction tools and testing apparatus during construction.

2.2 HAZARDOUS AREAS. Provide devices, materials, and equipment for installation in hazardous areas that are specifically approved for installation in hazardous areas of the Class, Division, and Group indicated, and are of construction that will ensure safe performance under conditions of proper use and maintenance. Provide devices, materials, and equipment meeting the requirements of the NEC, applicable state and local codes, and the authority enforcing these codes.

2.3 OUTLET AND DEVICE BOXES

2.3.1 General: Provide boxes not less than 2-inches deep, unless shallower boxes are required by structural conditions and are specifically accepted by the ENGINEER. Do not use box extensions to provide wiring space required by the NEC. For hollow masonry construction, provide boxes of sufficient depth so that conduit knockouts or hubs are in the masonry void space.

2.3.2 Sheet Steel (SS) Boxes: Provide zinc- or cadmium-plated boxes of the one-piece drawn type. Install 4-inch minimum octagonal boxes for ceiling outlets, except where smaller boxes are required for the particular fixture being installed. Use concrete type boxes in poured concrete slabs. Provide 2-inch by 4-inch minimum boxes for switches and receptacles. Provide plaster rings where required.

2.3.3 Cast Steel (CS) Boxes: Provide boxes of cast ferrous metal with gasketed, watertight, cast ferrous metal covers and stainless steel screws. Provide boxes with threaded conduit hubs and cast mounting lugs where lugs are required. Use Crouse-Hinds or Appleton Type FS or FD boxes, or equal..

2.3.4 Cast Aluminum (CA) Boxes: Provide boxes of cast, copper-free aluminum with gasketed, watertight, cast copper-free aluminum covers and stainless steel screws. Provide boxes with threaded conduit hubs and cast mounting lugs where lugs are required. Use Crouse-Hinds or Appleton Type FS or FD boxes, or approved equal. Use only with nonmetallic conduit systems. Use PVC components where moisture, corrosive conditions or physical abuse may occur, specifically including underground or upon or in the new wet well structure. Do not use phenolic fittings.

2.3.5 Nonmetallic (NM) Boxes: Provide fiberglass boxes with gasketed, watertight covers and stainless steel screws. Provide boxes with conduit hubs and any required mounting lugs. Use Crouse-Hinds, Stahlin, or equal.

2.3.6 Provide a box suitable for the conditions encountered at each outlet in the wiring or raceway system and sized in accordance with the NEC or City Electrical Code. Use the listed types unless otherwise indicated or accepted. Components for the project shall be carefully chosen; boxes must be of the same material as the raceway or conduit system (i.e., steel boxes with steel conduit), although in some instances steel boxes may be used with nonmetaliic conduits and aluminum boxes may be used with steel conduit.

- Types to be provided, Steel Raceway System:

Locations	Box Type
All	Cast steel
Exterior Locations, with:	
Exposed Raceways	Stainless steel(NEMA 4X)
Concealed Raceways	Stainless steel(NEMA 4X)
Concrete Encased Raceways	Cast steel
Class I, II, or III Hazardous Areas	Cast steel, NEMA 7
Interior Dry Locations, with:	
Exposed Rigid Conduit	Cast steel
Exposed EMT	Sheet steel
Concealed Raceways	Sheet steel

Concrete Encased Raceways	Cast steel
Lighting Circuits, Ceiling Portion	Sheet steel
Class I, II, or III Hazardous Areas	Cast steel, NEMA 7
Interior Wet Locations, with:	
Exposed Raceways	Stainless steel(NEMA 4X)]
Concealed Raceways	Cast steel
Concrete Encased Raceways	Cast steel
Lighting Circuits, Ceiling Portion	Sheet steel
Class I, II, or III Hazardous Areas	Cast steel, NEMA 7

- Types to be Provided, Aluminum Raceway System:

Locations	Box Type
All	Cast aluminum

- Types to be Provided, Nonmetallic Raceway System:

Locations	Box Type
All	Nonmetallic
Exposed Raceways	metal]
Concealed Raceways	Cast metal
Concrete Encased Raceways	Cast metal

- Types to be Provided: Device Plates

Locations	Plate Type
All	Metal
All Interior	Metal
Flush Mounted Boxes	Metal
Surface Mounted Cast Metal Boxes	Cast metal
Surface Mounted Sheet Metal Boxes	Cast metal

2.4 JUNCTION AND PULL BOXES

2.4.1 Utilize NEMA 4X 316 stainless steel or fiberglass UV-rated watertight enclosures for all locations on the site (which is outdoor, wet or corrosive) unless approved by the Engineer.

2.4.2 Where outlet boxes are used as junction or pull boxes, use materials as specified under article 2.3, OUTLET AND DEVICE BOXES.

2.4.3 Where larger sheet steel boxes are required, utilize boxes of code-gauge, galvanized steel with full-access screw covers mounted with corrosion-resistant machine screws.

2.4.4 Where larger cast metal boxes are required, use neoprene gasketed, watertight boxes with hinged, cast metal full-access covers, stainless steel cover hardware, and drilled and tapped conduit entrances. Use Crouse-Hinds Series W, O.Z./Gedney Series Y boxes, or equal. For below grade conduit, use Crouse-Hinds Type WJBF, O.Z./Gedney Series YR, or equal, minimum size 8-inches by 8-inches by 6-inches. For hazardous areas, use boxes applicable for the location and hazardous atmosphere present.

2.4.5 Where larger nonmetallic boxes are required, they shall be gasketed, watertight, corrosive resistant, and have a hinged, full-access screw cover. The hinge and machine screws shall be stainless steel. The box and cover shall be of high impact strength fiberglass-reinforced polyester material with stability to high heat. The boxes shall have conduit hubs and any required mounting lugs. The minimum size shall be 7-inches by 10-inches by 6-1/2-inches deep. Use Crouse-Hinds, or equal, Type NJB boxes.

2.4.6 Where subject to traffic loads, use concrete boxes of reinforced, cast concrete, 10-inches by 17-inches minimum inside dimensions, Brooks Products, Inc., No. 3-1/2T, Quikset W.17 Associated, or equal. Box cast iron cover shall be labeled as electrical box, junction box, pull box, etc. Boxes shall be approved by the Engineer.

2.5 TERMINAL JUNCTION BOXES (TJB)

2.5.1 Provide hinged-cover terminal junction boxes of the required type and size where indicated.

2.5.2 Utilize NEMA 12 enclosures for indoor dry locations. Utilize NEMA 4X watertight enclosures, as described under article 2.4, JUNCTION AND PULL BOXES, for outdoor or wet locations.

2.5.3 Provide terminal blocks with a separate connection point for each conductor entering or leaving the box. Provide 25% spare terminal points for CITY use following completion of installation. Paint interior surfaces with white enamel or lacquer.

2.6 TELEPHONE TERMINAL CABINETS. NA

2.7 WIRING DEVICES. Acceptable Manufacturers. Universal Electric, Omron, Leviton, Hubbell Inc., Thomas & Betts Corp., Eaton, ABB, Rockwell Allen Bradley, Cutler Hammer, Federal Pacific, General Electric, ITE, Siemens.

2.7.1 Switches:

- General Use Switches: Provide specification grade, totally-enclosed, ac type, quiet tumbler switches meeting NEMA WD 1 performance standards and Federal Specification W-S-896E, and capable of control of 100 percent tungsten filament, fluorescent lamp and LED loads. Use switches rated at 20 amps, 120/277 volts. Provide operating handles colored gray. Switches shall have screw terminals.

- Weatherproof Switches: Use switches mounted in a cast metal box with gasketed, weatherproof device plate.

- Switches with Pilot Lights: Provide switches with 125-volt, neon light with red jewel, or lighted toggle which is lighted when the switch is OFF.

2.7.2 Receptacles: Single and Duplex: Provide specification grade receptacles meeting NEMA WD 1 performance standards and Federal Specification W-C-596. Use two-pole, three-wire grounding type receptacles rated 20 amps, 125 volts, NEMA configuration 5-20R and with screw type wire terminals suitable for No. 10 AWG. Provide high strength thermoplastic bases colored gray.

2.7.4 Weatherproof Receptacles: Receptacles shall be specified above mounted in a cast metal box with gasketed, weatherproof device plate as specified below.

2.7.5 Ground Fault Interrupter (GFI) Receptacles: Provide duplex specification grade GFI receptacles tripping at 5 milliamps; rated 20 amps, 120 volts, NEMA configuration 5-20R and capable of interrupting 1,000 amps without damage. Use units meeting NEMA WD 1, fitting standard sized outlet boxes, having No. 12 AWG copper TW insulated pigtails, having provision for testing, and gray in color. Use standard model where ground fault protection is needed at an individual location. Use feed-thru model where ground fault protection is specified for "downstream" conventional receptacles. Provide receptacles accepting standard device plates.

2.7.6 Telephone Outlets: NA.

2.7.7 Device Plates: Provide plates fitting closely and tightly to the box on which they are to be installed. On surface mounted boxes, provide plates which do not extend beyond the sides of the box unless the plates do not have sharp corners or edges. Use plate material compatible with the box material such that galvanic corrosion of the plate and/or box does not occur. Acceptable Manufacturers. Universal Electric, Omron, Leviton, Hubbell Inc., Thomas&Betts Corp., Eaton, ABB, Rockwell Allen Bradley, Cutler Hammer, Federal Pacific, General Electric, ITE, Siemens.

- Plastic (P) Plates: Do not use.Metal (M) Plates: Provide specification grade, one-piece, 0.040-inch nominal minimal thickness, No. 430 satin finish stainless steel device plates with oval-head, matching mounting screws.

- Engraved Plates: Where device titles are indicated, provide device plates engraved with the designated titles. Provide engraved letters, numbers, or characters 3/16-inch high with filler of white color.

- Cast Metal (CM) Plates: Provide cast metal device plates of ferrous metal or copper free aluminum with gaskets and stainless steel screws with oval heads.

- Weatherproof (WP) Plates: Where weatherproof receptacles are designated or required, the receptacle shall be installed in the specified box with a gasketed, weatherproof, cast metal or stainless steel cover plate with individual cap over each receptacle opening and stainless steel mounting screws. Utilize plates with caps held tightly closed with stainless steel springs when receptacle is not in use.Weatherproof Switches. Any and all exterior switches shall be installed in the specified box with a gasketed, weatherproof, cast metal cover plate with an external operator for the internal switch and with stainless steel mounting screws.

- Raised Sheet Metal (SM) Plates: Provide 1/2-inch high zinc or cadmium-plated steel device plates designed for one-piece drawn type sheet steel boxes.

2.7 LIGHTING AND POWER DISTRIBUTION PANELBOARD

2.7.1 General. Provide circuit breaker panelboard including in motor control center meeting standards established by UL, NEMA PB 1, and the NEC. Provide panel UL labeled for that use.

2.7.2 Furnish panel with fully rated short circuit equipment rating. Series connected equipment ratings are not permitted. Provide panel rated for connection to an electric system having an available amperes rms symmetrical short circuit current of 18,000 208Y/120 volts. Provide panelboard and circuit breakers suitable for use with 75 degrees C wire at full 75 degrees C ampacity.

2.7.3 Cabinets: Furnish boxes large enough to provide a minimum wiring gutter space on both sides and top and bottom of 4-inches by 4-inches minimum. Provide flush or surface mounted box as indicated manufactured with reinforced steel frame and code-gauge, hot-dip galvanized sheet steel. Utilize front trim the same size as the box for surface mounted panelboards and 3/4-inch larger all around than the box for flush mounted panelboards. Panel covers shall be installed with direct screw connections. Adjustable clamps shall not be used. Utilize fronts having doors with concealed hinges and flush type lock and catch device. Provide multipoint locking devices for all doors over 30-inches in height. Key all locks alike, and furnish two milled type keys with each lock. Furnish on door interior a metal directory frame with transparent plastic face and enclosed directory card. Furnish an engraved, laminated plastic nameplate screwed (no adhesives) to the cabinet exterior face indicating the panelboard designation, service voltage, and phases. Nameplates shall be black engraved to a white core. Letter height shall be 1/4 inch.

2.7.4 Interiors:

- Furnish factory assembled panelboard interiors complete with circuit breakers as shown. In addition, space for future circuit breakers shall be provided with easily removable front cover. Utilize panelboards with interiors designed so that circuit breakers can be replaced without disturbing adjacent circuit breakers or without removing the main bus.

- Provide copper bus bars full sized throughout their length. Make complete provisions for mounting future circuit breakers throughout the full length of the bus. Provide all machining, drilling, or tapping required to add or change circuit breakers in the future. Bolt together and rigidly support bus bars and connection straps on molded insulators.

- Furnish an insulated neutral bus bar rated the same as the phase bus bars and having at least one terminal screw for each branch circuit. Furnish a copper ground bus bar installed on the panelboard frame, bonded to the box, and containing at least one terminal screw for each circuit. Provide solderless main lugs for main, neutral, and ground bus bars. Provide sub-feed or thru-feed lugs where indicated. Provide lugs and connection points on phase, neutral, and ground buses suitable for copper conductors.

2.7.5 Circuit Breakers:

- Furnish indicating type molded circuit breakers providing ON/OFF and TRIPPED positions of the operating handle. Furnish thermal magnetic, quick-make, quick-break circuit breakers which are non interchangeable in accordance with the AEC. Do not use tandem or dual circuit breakers in normal single-pole spaces. Do not use single-pole circuit breakers with handle ties where multiple circuit breakers are indicated. Utilize multi-pole circuit breakers designed so that an overload on one pole automatically causes all poles to open. Provide circuit breakers meeting requirements of NEMA AB 1. Install bolt-on circuit breakers in all panelboards. Provide circuit breaker handle

padlocking provisions where indicated or required.

- Where ground fault interrupter (GFI) circuit breakers are indicated or required by the NEC, provide a unit containing a conventional thermal magnetic trip and a ground fault sensor rated to trip the circuit breaker in approximately 0.025 second for a 5-milliampere ground fault (UL Class A sensitivity). Utilize a ground fault sensor having the same rating as the circuit breaker and having a push-to-test button.

- Acceptable Manufacturers. Universal Electric, Omron, Leviton, Hubbell Inc., Thomas & Betts Corp., Eaton, ABB, Rockwell Allen Bradley, Cutler Hammer, Federal Pacific, General Electric, ITE, Siemens.

2.8 CIRCUIT BREAKERS, INDIVIDUAL, 600 VOLTS AND LESS

2.8.1 Mount individual circuit breakers in NEMA 12 industrial use enclosure unless otherwise indicated. Provide circuit breakers with handles that can be locked in the OFF position. Interlock enclosure and circuit breaker to prevent opening the cover with the circuit breaker in the ON position. Provide quick-make, quick-break, thermal magnetic circuit breakers of the indicating type showing ON/OFF and TRIPPED positions of the operating handle.

2.8.2 Do not use single-pole circuit breakers with handle ties where multi-pole circuit breakers are indicated. Utilize multi-pole circuit breakers designed so that an overload on one pole automatically causes all poles to open. Provide circuit breakers meeting the requirements of NEMA AB 1 and having a minimum interrupting rating of amps rms symmetrical at volts. Provide circuit breakers with terminals suitable for use with 75 degrees C wire at full 75 degrees C ampacity.

2.9 FUSED SWITCHES, INDIVIDUAL, 600 VOLTS AND LESS

2.9.1 Mount individual fused switches in NEMA 12 industrial use enclosures unless otherwise indicated. Provide NEMA 4X 316 stainless steel raintight enclosure for fused switches mounted outdoors. Provide fused switches that can be locked in the OFF position. Interlock enclosure and switch to prevent opening the cover with the switch in the ON position. Provide fused switches which are quick-make, quick-break, motor rated, load-break, heavy-duty (HD) type having external marking clearly indicating ON and OFF positions. Provide fuses of the current ratings indicated and types specified herein. Utilize fuse mountings that reject Class H fuses and will accept only the current-limiting fuses specified.

2.9.2 Provide fused switches meeting the requirements of NEMA KS 1 and UL listed for application to a system having an available short circuit current of _____ amps rms symmetrical. Provide switches with terminals suitable for use with 75 degrees C wire at full 75 degrees C ampacity.

2.10 NONFUSED SWITCHES, INDIVIDUAL, 600 VOLTS AND LESS. Mount individual switches in NEMA 12 industrial use enclosure unless otherwise indicated. Provide NEMA 4X 316 stainless steel raintight enclosure for switches mounted outdoors. Provide switches that can be locked in the OFF position. Interlock enclosure and switches to prevent opening the cover with the switch in the ON position. Provide switches which are quick-make, quick-break, motor rated, load-break, heavy-duty (HD) type having external marking clearly indicating ON and OFF positions. Furnish switches meeting the requirements of NEMA KS 1. Provide switches suitable for use with 75 degrees C wire at full 75 degrees C ampacity.

2.11 FUSES, 600 VOLTS AND LESS.

2.11.1 Provide a complete set of current-limiting fuses wherever fuses are indicated. Supply a set of six spare fuses of each type and each current rating installed. Utilize fuses that fit mountings specified with switches and which provide features rejecting Class H fuses. Provide the following types:

- For motor and transformer circuits, 600 volts and less, 0 to 600 amps, UL Class RK-1 with time delay, Bussmann Type LPS-RK, Shawmut Type A6D-R, or equal.

- For motor and transformer circuits, 250 volts and less, 0 to 600 amps, UL Class RK-1 with time delay, Bussmann Type LPN-RK, Shawmut Type A2D-R, or equal.

- For feeder and service circuits, 600 volts and less, 0 to 600 amps, UL Class RK-1, Bussmann Type KTS-R, Shawmut Type A6K-R, or equal.

- For feeder and service circuits, 250 volts and less, 0 to 600 amps, UL Class RK-1, Bussmann Type KTN-R, Shawmut Type A2K-R, or equal.

- For feeder and service circuits, 600 volts and less, 601 to 6,000 amps, UL Class L, Bussmann Type KRP-C, Shawmut Type A4BY, or equal.

2.12 PUSHBUTTONS, INDICATING LIGHTS, AND SELECTOR SWITCHES. Acceptable Manufacturers. Universal Electric, Omron, Leviton, Hubbell Inc., Thomas&Betts Corp., Eaton, ABB, Rockwell Allen Bradley, Cutler Hammer, Federal Pacific, General Electric, ITE, Siemens.

2.12.1 For non-hazardous, indoor, dry locations, including motor control centers, control panels, and individual stations, provide heavy-duty, oil tight type pushbuttons, indicating lights, selector switches, and stations for these devices.

2.12.2 For non-hazardous, outdoor, or normally wet locations, or where otherwise indicated, provide heavy-duty corrosion-resistant, watertight type pushbuttons, indicating lights, or selector switches mounted in NEMA 4X 316 stainless steel watertight enclosures. Provide special gasketing required to make complete station watertight.

2.12.3 Provide devices meeting the requirements of NEMA ICS 2, and having individual, extra large nameplates indicating their specific function. Provide pushbutton stations with laminated plastic nameplates indicating the drive they control. Provide contacts with NEMA designation rating A600.

2.12.4 For hazardous locations, enclosures for push buttons, indicating lights and selector switches shall be approved for classified areas.

2.12.5 Utilize selector switches having standard operating levers. Make all indicating lights push to test type. Provide ON or START pushbuttons colored black. Provide OFF or STOP pushbuttons colored red.

2.13 TERMINAL BLOCKS 600 VOLTS AND LESS

2.13.1 Provide 600-volts terminal blocks for termination of all control circuits entering or leaving

equipment, panels, or boxes. Provide screw clamp compression, dead front barrier type terminal blocks with current bar providing direct contact with wire between the compression screw and yoke. Provide yoke, current bar, and clamping screw constructed of high strength and high conductivity metal. Utilize yoke that guides all strands of wire into the terminal. Utilize current bar providing dependable vibration-proof connection. Supply terminals constructed to allow connection of wire without any special preparation other than stripping. Rail mount individual terminals to create a complete assembly and provide terminals constructed such that jumpers can be installed with no loss of space on terminal or rail.

2.13.2 Size all terminal block components to allow insertion of all necessary wire sizes and types. Supply terminal blocks with marking system allowing the use of preprinted or field-marked tags. Supply CSA certified and UL approved terminal blocks manufactured by Weidmuller, Ideal, Electrovert, or equal. Provide terminal blocks with 25% spare termination points for the City's use following completion of installation.

2.14 CONTROL RELAYS

2.14.1 Provide magnetic control relays, NEMA Class A300 (300 volts, 10 amps continuous, 7,200VA make, 720VA break), industrial control type with field convertible contacts, and meeting the requirements of NEMA ICS 2. Provide Cutler-Hammer Type M-300, General Electric Type CR120A, or equal.

2.14.2 Where time delay relays are specified or required, unless otherwise noted, provide magnetic control relays with a timer attachment adjustable over the range specified on the Drawings.

2.14.3 Where latching (mechanically held) relays or motor thermal detector relays are specified, provide magnetic control relays with mechanical latch attachment with unlatching coil and coil clearing contacts. Utilize an attachment allowing easy manual latching and unlatching.

2.15 RESET TIMERS. Provide synchronous-motor-driven reset timers with a solenoid-operated clutch and suitable for semi-flush, panel mounting. Utilize timers with time range indicated and 10-amp, 120-volts contacts. Provide Eagle Signal Bulletin 125 timers, Automatic Timing and Controls Bulletin 305 timers, or equal.

2.16 ELAPSED TIME METERS. Provide synchronous-motor-driven, elapsed time meters, 0 to 99,999.9 hours range, non-reset type, suitable for semi-flush, panel mounting. Provide General Electric Type 240, 2-1/2-inch Big Look unit, Eagle Signal Bulletin 705 unit, or equal.

2.17 MAGNETIC CONTACTORS. Provide contactors of the NEMA sizes indicated. Mount contactors in NEMA 12 industrial use enclosures unless otherwise indicated. Utilize contactors manufactured and rated in accordance with NEMA ICS 2.

2.18 MAGNETIC LIGHTING CONTACTORS. Provide mechanically held lighting contactors of the current ratings indicated. Mount contactors in NEMA 12, dust-tight, drip-tight, industrial use enclosure unless otherwise indicated. Provide coil-clearing contacts on mechanically-held units. Comply with NEMA ICS 2.

2.19 AUTOMATIC TRANSFER SWITCHES. Acceptable Manufacturers. Rockwell Allen Bradley, ABB, General Electric Siemens, Eaton-Cutler Hammer, Leviton, Hubbell Inc., Thomas&Betts, Federal Pacific, or ITE.

2.19.1 Provide, where indicated, automatic load transfer switch with the continuous current capacity and withstand rating as indicated. Provide switches automatically transferring from normal to standby source on failure of the normal source.

2.19.2 Provide switch control with adjustable 0- to 5 -minute timers to permit a delay on transfer after power failure, and to permit a 10 minute delay on retransfer following restoration of normal power. Cause transfer to standby source to occur when any phase of the normal source drops below 80 - 85 percent of rated voltage and all phases of the standby source are at least 95 percent of rated voltage. Re-transfer shall occur when all phases of the normal source have returned to at least 90 percent of rated voltage.

2.19.2 Supply transfer switches which are mechanically held and electrically operated with operating current from the source to which load is being transferred. Supply switches constructed to prevent a neutral position and electrically and mechanically interlocked to prevent connection of the load simultaneously to both sources. Include a TEST/OFF/AUTOMATIC operation selector switch, the TEST position to simulate power failure, RED/GREEN lights indicating standby and normal switch position, and one normally open and one normally closed 5-amp, 120-volt, auxiliary contact for future remote indication of transfer.

2.19.3 Provide switch housed in a wall mounted NEMA 12 enclosure with lockable hinged front cover. Supply transfer switch suitable for use with 75 degrees C wire at full 75 degrees C ampacity.

2.20 CAPACITORS. NA

2.21 Not Used.

2.22 DRY TYPE SMALL POWER TRANSFORMERS (600-VOLTS AND LESS PRIMARY). Acceptable Manufacturers. Universal Electric, Omron, Leviton, Hubbell Inc., Thomas&Betts Corp., Eaton, ABB, Rockwell Allen Bradley, Cutler Hammer, Federal Pacific, General Electric, ITE, Siemens.

2.22.1 Provide self-cooled, two-winding, dry type transformer of the ratings indicated and built in accordance with the latest IEEE, ANSI, and NEMA standards. Utilize units with manufacturer's standard insulation class and standard temperature rise. For ratings 3 to 25 kava single-phase and 3 to 15 kava 3-phase, provide units with core and coils completely enclosed in a non-ventilated, NEMA 4X weatherproof enclosure. Utilize encapsulated windings on single-phase units 0 to 25 kva. On all transformers 15 kava and larger provide units with at least four, 2-1/2 percent, full capacity voltage taps; two above and two below normal voltage rating. On units 75 kva and larger, provide an impedance of 4.5% minimum.

2.22.2 Supply units where sound levels determined by tests in accordance with NEMA and ANSI standards do not exceed 45 decibels.

2.23 DRY TYPE, SHIELDED, ISOLATION TRANSFORMERS (600-VOLTS AND LESS PRIMARY). NA

2.24 LOW VOLTAGE SURGE PROTECTIVE EQUIPMENT

2.24.1 Provide secondary surge protective equipment consisting of a surge capacitor and surge

arrestor combination located where indicated on the Drawings. Utilize components for all surge protective equipment covered by this Specification, designed and tested in accordance with NEMA LA-1 and ANSI/IEEE C62.1.

2.24.2 Provide a surge capacitor impregnated with non-pcb biodegradable dielectric fluid. Include an integral discharge resistor which will drain the residual voltage to 50 volts crest in less than 5 minutes after the unit has been disconnected from the circuit.

2.24.3 Provide an arrestor consisting of an assembly of high strength metal oxide valve elements enclosed in a high strength, corrosion-resistant, molded resin housing.

2.24.4 Provide a capacitor and arrestor having a mounting nipple, flat washer, and nut suitable for knockout mounting. Install capacitors and arrestors in NEMA 4X (stainless steel) enclosures.

3.0 CONSTRUCTION

3.1 OUTLET AND DEVICE BOXES

3.1.1 Installation. Mount boxes at the following heights unless otherwise required by the Americans with Disabilities Act (heights are to the centerline of the box):

- Wall switches 48-inches above floor
- Thermostats 54-inches above floor
- Wall telephone outlets: As shown on drawings
- Wall mounted telephone: As shown on drawings
- Office, Lab Receptacles: As shown on drawings
- Where above heights do not suit the building construction or finish, locate boxes where directed by the ENGINEER.

3.1.2 Locations indicated are approximate. Study the Drawings in relation to spaces and equipment surrounding each outlet. When necessary, with the approval of the ENGINEER, relocate outlets to avoid interference with mechanical equipment or structural features. Locate all light switches on lock side of doors. Locate all light fixture outlets in a symmetrical pattern according to the room layout unless otherwise indicated.

3.1.3 Mount all boxes plumb and level. Use flush mounted boxes with concealed conduits. Make edges of boxes flush with finished surface. Provide proper type extension rings or plaster covers for this purpose. For flush mounted boxes, make holes in the surrounding surface no larger than required to receive the box.

3.1.4 Install boxes in a secure, substantial manner supported independently of conduit by attachment to the building structure or a structural member. Fasten boxes with bolts and expansion shields on concrete or brick, toggle bolts on hollow masonry units, and machine screws or welded, threaded studs on steelwork. Threaded studs driven in by a powder charge and provided with lock washers and nuts are acceptable in lieu of expansion shields. Boxes embedded in concrete or masonry need not be additionally supported. Utilize galvanized mounting hardware in industrial areas.

3.1.5 Provide flush or recessed lighting fixtures with separate junction boxes when required by the fixture terminal temperature. Where boxes support fixtures, provide proper means of

attachment with adequate strength.

3.1.6 Open no more knockouts in sheet steel boxes than are actually required. Seal any used openings in any type box.

3.2 JUNCTION AND PULL BOXES

3.2.1 Where indicated on the Drawings, and where necessary to terminate, tap-off, or redirect multiple conduit runs, provide and install appropriately designed junction boxes. Furnish and install pull boxes where necessary in the raceway system to facilitate conductor installation. Provide pull boxes to limit conduit runs to less than 150-feet and to contain no more than the equivalent of three right-angle bends unless accepted by the ENGINEER.

3.2.2 Types to be Provided. Use boxes of the types listed for specific locations under article 2.3, OUTLET AND DEVICE BOXES. Use outlet boxes as junction boxes and pull boxes wherever possible and allowed by applicable codes. Provide cast concrete boxes for below-grade conduit. Provide stainless steel NEMA 4X for above-grade locations.

3.2.3 Installation. Make all boxes accessible. Mount all boxes plumb and level. Boxes may be surface mounted with unconcealed conduits in industrial-style facilities, lift stations, etc. Mount boxes in a secure, substantial manner, supported independently of conduit by attachment to the building structure or a structural member. Fasten boxes with bolts and expansion shields on concrete or brick, toggle bolts on hollow masonry units, and machine screws or welded threaded studs on steelwork. Threaded studs driven in by a powder charge and provided with lock washers and nuts are acceptable in lieu of expansion shields. Boxes embedded in concrete or masonry need not be additionally supported. Utilize galvanized mounting hardware in existing buildings. Install boxes for conduits under grade flush with finished grade in locations outside of paved areas, roadways, or walkways. If adjacent structure is available, the box may be mounted on the structure surface just above finished grade in an accessible but unobtrusive location. If it is found desirable to locate boxes in paved areas, roadways, or walkways, obtain ENGINEER's approval and utilize boxes and covers suitable for the weights to which they may be subjected.

3.3 TERMINAL JUNCTION BOXES (TJB). Install in accordance with all the requirements detailed under article 3.2, JUNCTION AND PULL BOXES above. Label each block and terminal with a permanently attached, non-destructible tag.

3.4 TELEPHONE TERMINAL CABINETS. Provide by special specification.

3.5 WIRING DEVICES

3.5.1 Switches: Mount switches at the heights indicated under article 3.1, OUTLET AND DEVICE BOXES. Mount switches for switch operation in the vertical position.

3.5.2 Receptacles: Mount receptacles at heights indicated under article 3.1, OUTLET AND DEVICE BOXES. Mount receptacles with grounding slot down except where horizontal mounting is indicated, in which case mount with neutral slot down. Ground receptables to boxes with grounding wire. Mount weatherproof receptacles with the hinge for the protective cover above (not at side, or below) the receptacle opening.

3.5.3 Special Purpose Receptacles: Locate special purpose receptacles where shown. Install and mount the receptacles in accordance with the manufacturer's instructions and the applicable codes.

3.6 MULTIOUTLET SURFACE RACEWAY SYSTEM: Locate multioutlet surface raceway systems where shown and install in accordance with the manufacturer's instructions.

3.7 Not Used.

3.8 DEVICE PLATES: Installation: Securely fasten device plates to switch or receptacle boxes or the wiring device contained therein. Install device plates used with flush mounted boxes with all four edges in continuous contact with the finished wall surfaces without the use of mats or similar materials. Plaster fillings will not be acceptable. Install device plates vertically or horizontally with an alignment tolerance of 1/16-inch. Do not use sectional type device plates.

3.9 LIGHTING AND DISTRIBUTION PANELBOARDS. Mount panelboards securely where indicated, plumb, in-line, and square with walls. Unless otherwise indicated, mount panelboard with top of its cabinet approximately 6-feet above the floor. Provide a typewritten circuit directory under a metal-framed transparent plastic cover inside each panelboard. Provide an engraved, laminated plastic nameplate on the outside of the panelboard showing the panelboard designation, voltage, and phases.

3.10 DRY TYPE TRANSFORMERS (600-VOLTS AND LESS PRIMARY). Mount transformers approximately where indicated. Load any vibration isolators external to the unit properly and provide complete isolation with no direct transformer unit metal in contact with the mounting surface.

3.10.1 Connect electrical circuits to transformers by means of moisture proof, flexible conduit in a manner that prevents transformer vibrations from being transmitted to the building or other equipment.

3.10.2 Ground neutrals and enclosures of all transformers and all moisture proof flexible conduit in accordance with applicable codes and as otherwise may be indicated. Connect voltage taps on all transformers to give as close as possible to rated output voltage under normal plant load conditions.

3.11 DRY TYPE, SHIELDED, ISOLATION TRANSFORMERS (600-VOLTS AND LESS PRIMARY). Follow instructions for DRY TYPE TRANSFORMERS (600-VOLTS AND LESS PRIMARY) above. In addition, ground isolation shields to the unit enclosure with a conductor of the same material, and at least as big, as the shield ground lead provided with the unit.

1.0 CONDUITS AND RACEWAYS. Furnish and install conduits and raceways as indicated on the Contract Drawings and herein specified. Comply with the General Conditions, General Requirements and requirements of these and the special specifications where applicable concerning definitions, guarantees, submittals, as-builts, etc. as applicable to work of this Section.

1.2 SUBMITTALS

1.2.1 Shop Drawings: Layout drawings of exposed raceways in public spaces.

1.1.1 Contractor to provide a list of materials with product data.

1.2 QUALITY ASSURANCE.

1.2.1 Listing and Labeling: Provide raceways and boxes specified in this Section that are listed and labeled. The Terms "Listed" and "Labeled": As defined in NFPA 70, Article 100.

1.3.2 Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" as defined in OSHA Regulation 1910.7.Comply with NECA's "Standard of Installation" and NFPA 70.

1.4 COORDINATION. Coordinate layout and installation of raceways and boxes with other construction elements to ensure adequate headroom, working clearance, and access.

2.0 MATERIALS AND PRODUCTS

2.1 CONDUITS AND RACEWAYS

2.1.1 Steel Material: Galvanized raceways underground and in wet, damp or corrosive atmosphere with 40 mil PVC coating.

2.1.2 All Conduit Shall Be Metallic Unless Otherwise Indicated or Noted: Metallic conduit incorporated in the work shall comply with applicable divisions of the National and American Standards Association publications.

- Rigid Steel Conduit: full weight pipe, galvanized, threaded.
- Intermediate Metal Conduit (IMC): Lightweight steel pipe, galvanized, threaded.
- Aluminum Conduit: Not allowed.
- Electro-Metallic Tubing (EMT): Thin wall pipe, galvanized, threadless.
- Flexible Metal Conduit: Continuous single strip, aluminum or galvanized steel.
- Polyvinyl Chloride Jacketed Conduit (PVC): Provide only where noted:
    - Self-extinguishing, NEMA TC-2, for 90 deg C rated cable
    - NEMA TC-6 for communication wiring only shall be flame retardant.

- Concrete encased and direct burial: Schedule 40.
- Buried locations subject to heavy vehicular traffic: Schedule 80.
- Elbows: PVC coated galvanized rigid steel for direct burial.

2.1.3. Wireways: Complete with all fittings and accessories. Size as noted, baked enamel finish inside and outside, approved for support at minimum 10 feet on centers.

- Interior Use: Hinged cover and base, minimum thickness 16 gauge galvanized steel.

- Exterior Use: Hinged cover and base, minimum No. 14 gauge galvanized steel, weatherproof and gasketed.

2.1.4 Surface Metal Raceways: Complete with all fittings and accessories. Size as noted, baked enamel finish inside and out:

- Snap-on covers, minimum No. 20 gauge galvanized steel.

- Wiremold Co., Walker Parkersburg Textron, Power-Strut or equal.

2.1.5 Raceway Fittings:

- Rigid Steel and Intermediate Metal Conduits: Non-split, threaded, steel or malleable iron. Zinc die cast not permitted.

- Electro-Metallic Tubing: Set screw type except waterproof compression type in concrete and for outdoor installation. Zinc die cast fittings are not permitted.

- Flexible Metallic Conduit: Angle wedge type with insulated throat.

- Bushings: Metallic insulated type.

- Weatherproof or Dust-tight Installations: Liquid-tight with sealing ring and insulated throat.

- Hazardous Locations: Cast, copper-free aluminum, threaded covers.

- Provide raceways complete with boxes, fittings and accessories.

2.1.6 Sleeves:

- Exterior Non-Membrane Waterproofed Walls or Interior Load Bearing Walls: Galvanized cast iron, galvanized steel or wrought iron with continuously welded center flange.

- Exterior Non-Membrane Waterproof Roofs: Galvanized cast iron, flashing flange and clamping ring. Josam 26440 Series or equal.

- Exterior Membrane Waterproof Walls, Floors and Roofs: Galvanized cast iron, flashing flange and clamping ring, equal to Josam 26400 Series or O.Z. type WSK or FSK.

- Interior Membrane Waterproof Floors: Galvanized cast iron, flashing flange and

clamping ring. Extend two inches above floor with pipe nipples. Clamp to flashing. Josam 26420 Series or O.Z. type WSL or FSK or equal.

2.1.7 Seals:

- Raceways in Waterproof Sleeves: O.Z. Type WSK through wall seal.
- Raceways in Non-Watertight Sleeves: Sealing compound.
- Thruwall Cable Seals: O.Z. Type WSCS.
- Hazardous Areas, Cold Rooms Conductor Water Stops: Equal to Crouse-Hinds or Appleton type EYS, ESU, EYM, EYOM or SFM with matching sealing cement and fiber filler.

2.1.8 Expansion Fittings:

- Exposed and In Furred Spaces: Flexible conduit with external bonding jumper strip.
- In Slab: O.Z. Type AX or Appleton type XJ or XJF with ground continuity.

2.1.9. Cables in Raceways Through Sleeves: O.Z. type KSC compound or type C series terminators.

2.1.10 Fire Sealants. Provide when shown on the plans or directed by the Engineer.

2.2 BOXES

2.2.1 Outlet Boxes, except as otherwise required by construction, devices or wiring, as follows:

- Stamped or Welded Steel, 4-Inches, Square For Lighting Fixtures: 2-1/8 inch deep on ceiling, 3 inch deep in slab, and 2-1/8 inch deep in wall.
- In Wall For Receptacles and Switches: 4 inches square by 1-1/2 inch deep with raised covers and fixture studs where required. Through-the-wall type not permitted.
- In Wall For Telephone or Data: 5-inches square by 2-1/8 inch deep with raised covers and fixture studs where required. Through-the-wall type not permitted.
- Galvanized Cast-Iron or Aluminum With Threaded Hubs: 4 inch square, 2-inch deep on ceiling, and 4-inch square, 2-inch deep on wall.
- Boxes For Outdoors, Damp Locations and Wet Well Concrete Structure: Weatherproof, cast metal.
- In Hazardous Locations: Cast, copper-free aluminum.
- Boxes Without Fixture or Device: Provide with blank cover.

2.2.2 Junction and Pull Boxes:

- Galvanized Sheet Steel: Code size and gauge in accordance with voltage parameters.
- Covers: Screw-on, except as noted.
- With insulated supports for cables.
- Locations: As indicated, where required and accessible.
- Outdoors and Damp Locations: Galvanized cast iron or aluminum with threaded hubs and gaskets.
- Provide barriers or separate boxes between wiring energized from different systems; and emergency and normal wiring.

2.2.3 Not Used.

2.2.4 Manholes and Handholes:

- Precast concrete with reinforcement for H-20 bridge loading.
- Water stopped joints with cast-iron rings and covers
- Covers shall be permanently identified as electrical component.
- Inside dimensions as required by NEC 370 size by the Contractor.
- Complete with inserts, galvanized cable racks, insulated galvanized ladders, dry sumps, galvanized pulling irons, grounding, etc. necessary for complete and operational system.
- Manufactured by: Associated Concrete Products, Inc., Brooks Products, Inc., or equal.

2.2.5 Floor Boxes: Unless otherwise noted, galvanized cast iron with stainless steel covers and flanges suitable for conduit and devices indicated. Walkerbox 880 Series or equal.

3.0 INSTALLATION OF CONDUITS AND RACEWAYS

3.1.1 General Procedures:

- All conduit joints shall be cut square, threaded, reamed smooth and drawn up tight. Bends or offsets shall be made with standard conduit ells, field bends made with an approved bender or hickey, or hub-type conduit fittings. Number of bends per run shall conform to Code limitations.
- Paint male threads of field threaded conduit with homogenized blend of colloidal copper and rust and corrosion inhibitor pipe compound, Thomas and Betts Kopr-Shield or equal. Butt conduit ends.
- Conduits shall be secured to all boxes with locknuts and bushings in such manner that

each system shall be electrically continuous throughout.

- Conduits shall be securely fastened in place on maximum 4 foot intervals; and within 12" of every outlet box, hangers, supports, or fastenings shall be provided at each elbow and at end of each straight run terminating at a box or cabinet.

- Furnish and install pullboxes where required by Code and where necessary in the raceway system to facilitate conductor installation. In general, conduit runs of more than 100 ft., or with more than three right-angle bends, shall have a pullbox installed at a convenient intermediate location. Support boxes independently of raceways, walls and partitions. Boxes shall have removable screw covers and shall be accessible.

3.1.2 Coordination. Coordinate layout and installation of raceways and boxes with other construction e elements to ensure adequate headroom, working clearance, and access. Raceways shall be run in the open, unless and except as noted. Raceways shall not be buried in waffle floors.

3.1.3 Supports Shall Be As Follows:

- Ceiling trapeze, strap hangers, or wall brackets.

- U-bolt or pipe straps at each grating level of riser raceways.

- Raceways shall be secured to support with pipe straps or U-bolts.

- Spacing shall be a maximum 10 foot on centers for metallic conduit and wireways.

- Supports Shall Be Mounted To Structure With:

    - Toggle bolts on hollow masonry.
    - Expansion shields or inserts on concrete and brick.
    - Machine screws on metal and fiberglass
    - Wood screws on wood.
    - Nails, rawl plugs or wood plugs shall not be permitted.

3.1.4 Raceway Runs. Exposed raceways and raceways in hung ceilings shall be run parallel with or at right angles to walls.

- Clearance From Water, Steam or Other Piping: Minimum three inches separation from hot water pipes, except one inch from pipe cover at crossings.

- Keep raceways clear of motor foundations and underside of boilers.

- Raceways for hung ceiling shall be run in hung ceilings.

- Run raceways in walls vertically.

- Maintain grounding continuity of interrupted metallic raceways with ground conductor, and in flexible conduit for feeders and motor terminal connections.
- Include equipment grounding conductor in exposed, damp or wet locations.

- Empty Raceways Over 10-feet Long: Provide with fish or pull wire, galvanized steel or nylon rope.

3.1.5 Raceways Located Underground, Beyond Building:

- Minimum 24-inches top cover, 30-inch top cover in areas subject to vehicular traffic.
- Similar to O.Z. type CRC Series.
- Manhole Entries: Through end bells perpendicular to entering wall.
- Anchor raceways to prevent movement.
- After Installation: Pass stiff bristle, mandrel (85 percent of raceway diameter) and plug.
- Placement: Over well-tamped trench bottom and on concrete blocks, five feet on centers. Provide non-metallic spacers.
- Joints: Minimum six inches apart and staggered. Provide watertight joints.

3.1.6 Raceways Located Underground, Under Buildings:

- Use PVC-coated galvanized steel conduit for bends.
- Transition from PVC to steel must occur underground.
- Separate pullboxes/handholes for normal and emergency circuits.
- Concrete encasement to be continuous with floor.

3.1.7 Fire Sealants. When directed by the Engineer.

3.1.8 Vibration and Noise Control. As provided in the special specifications.

3.1.9 Rigid Steel Conduit:

- In slabs, maximum outside diameter not to exceed 1/3 of the slab thickness.
- Direct Buried Conduit: Provide 40 mil PVC coated conduit.
- Under Building: Concrete encase.
- Minimum one-inch cover in concrete fill.

3.1.10 Intermediate Metal Conduit: Same as Rigid Steel.

- Do not use in hazardous locations or direct burial.

- Do not use for cables installed by Utility Company.

3.1.11 EMT: (Electro-Metallic Tubing). Install in interior of existing building. Permitted in slabs (see 3. 1.C) provided:

- Maximum outside diameter not greater than 1/3 slab thickness.
- Located in center third.
- Provide with equipment grounding conductor, adjust conduit size as required.
- Use only compression fittings and couplings.

3.1.12 Not Used.

3.1.13 Flexible Metallic Conduit:

- For short motor or vibrating equipment connections where rigid conduit is impracticable.
- From Outlet Box to Recessed Lighting Fixture: Minimum four feet, maximum six-foot length.
- For Final Connection to Motor Terminal Box, Transformers and Other Vibrating Equipment: With polyvinyl sheathing and ground conductor. Minimum length: 18 inches with minimum 50 percent slack. Connect ground conductor to enclosure or raceway at each end.
- For expansion joint crossings, cross at right angles and anchor ends.
- Provide liquid tight flexible conduit with separate insulated stranded copper equipment ground conductor for connections in area exposed to weather, damp locations and connections to transformers enclosures regardless of location. Use for all connections to motors.

3.1.14 Plastic Conduit: (PVC)

- Permitted Use: Only in “site” or below floor slab. Do not use in general interior use.
- Cut ends square, ream smooth, wipe clean apply approved solvent weld cement and quarter turn as drawing up tight to shoulder. Seal joints watertight.
- Convert to steel conduit through adaptors when entering building and for risers.
- Clearance from hot water, heaters or and steam lines: Three feet minimum.
- Provide ground wire with power wiring and increase size if required.
- Under roads, roadways, parking areas, and outside the walls of the building: concrete encase underground.

3.1.15 Outlet Boxes:

- Set square and true with building finish and secure to building structure by adjustable strap irons.

- Verify outlet locations in finished spaces with Drawings of interior details and finishes.

- Provide barriers between switches connected to different phases for voltages exceeding 150 volts to ground.

3.1.16 Panel, Junction and Pull Boxes:

- Location: Clear of other work. Mount junction and pull boxes as described above and maintain accessibility. Support from building structure, independent of conduit.

- Outlet boxes for fixtures recessed in hung ceiling: NA.

- Motor Terminal Boxes: Coordinate with motor branch circuit conduit and wiring.

3.2 TESTS. Test continuity and resistance of feeder conduits from service to point of final distribution using 1 conductor return with a maximum 25 ohms resistance.

1.0 CONDUCTORS, 600 VOLTS AND BELOW. Provide and install insulated, solid and/or stranded type wire conductors and wire connectors for circuit voltage of 600 volts or less as herein specified. Comply with the General Conditions, General Requirements, these specifications and the special specifications concerning definitions, guarantees, submittals, as-builts, clean-up, etc. as applicable to work of this Section.

2.0 MATERIALS AND PRODUCTS

2.1 CONDUCTORS AND INSULATION

2.1.1 Insulated wire conductors for circuit voltage, 600 volts or less, shall be copper. Conductors shall have UL approved 600 volt insulation of type specified below or elsewhere in the Specifications.

2.1.2 Branch Circuits and Feeders - Lighting and Power:

- #10 AWG and smaller, solid wire.
- #8 AWG and larger, stranded type.
- Insulation @ 75 degrees C Type THW, THWN, XHHW, THHN.

2.1.3 For conductors installed in areas subjected to temperatures exceeding 140 degrees F., including terminating in incandescent lighting fixtures and installed through or into housing containing ballasts, provide type FEPB, RHH or THHN.

2.1.4 For conductors installed in exposed conduit outside of buildings and conduit within or just under roofing material, provide type XHHW.

2.1.5 Control Circuits for Mechanical Equipment: Use 600 volt Underwriters' type THWN conductors except where subject to abnormally high temperatures such as on or near heater. Under these conditions, use type FEPB.

2.1.6 Conductors for Class 2 or 3 Bell Buzzer or Intercom Systems: Synthetic plastic insulation type.

2.1.7 Conductor for Intercom System: Jacketed multiconductor stranded type.

2.1.8 Conductors for Music and Paging Systems: NA

2.1.9 For Speakers: Stranded No. 18 AWG size jacketed twisted pair.

2.1.10 For Microphone: Shielded No. 2

2.1.11 Conductor for Door Status and Lock: Stranded jacketed twisted pair for Class 2 or 3 systems, No. 18 A.W.G. size.

2.1.12 Conductors for Fire Protective Signaling Systems: Solid No. 14 A.W.G. size minimum.

2.1.13 Conductors for Cable Tray Systems: U.L. listed single or multiconductor type, identified for use.

2.2 GENERAL FABRICATION

2.2.1 For General Wiring: Use type THHN-THWN where operating temperature is 90 degrees F or less, or shall use type AVA-AWM where temperature exceeds 90 degrees F or where exceeding 140 degrees provide type FEPB, RHH or THHN.

2.2.2 For Wiring Individually Mounted Lighting Fixtures or Lamp Holders: Stranded type SF-2 or PGF fixture wire.

2.2.3 For General Wiring: Use No. 10 A.W.G. size and smaller solid type where flexibility or regular movement is not required, or use No. 8 A.W.G. stranded type where flexibility or regular movement is required.

2.2.4 The minimum conductor size for general wiring shall be No. 12 A.W.G. except as indicated otherwise on the Drawings.

2.2.5 Connectors for #10 conductors and smaller UL listed for 600 volts, approved for use with copper and/or cone shaped, expandable coil spring insert, insulated with a nylon shell and two wings placed opposite to each other to service as a "built-in" wrench. Shell shall be molded one-piece as manufactured by Ideal Industries "Wing Nut" connectors.

2.2.6 Connectors for #8 AWG and larger shall be screw pressure lugs made of high strength structural aluminum alloy and UL approved for use with copper wire as manufactured by Ilsco, T & B Burndy or O.Z. Companies.

2.2.7 Conductor insulation type, size and UL approval shall be printed with permanent white paint on all conductor insulation continually repeating.

2.2.8 Provide all conductors used for power, lighting, signal and communications systems (operating at 600 volts and below) with a minimum insulation rating of 600 volts.

2.2.9 Minimum Size of Conductors: #12 AWG copper for power and lighting, #14 AWG copper for controls and low voltage wiring (less than 120 volts) if adequate.

2.2.10 All conductors shall be new and shall have been manufactured within 12 months of the date of delivery to the job-site and continuously stored where protected from the sun, heat or weather.

2.2.11 Deliver all conductors to the site on their original cable reels or in their original unbroken packages.

2.2.12 Provide all conductor packages and cable reels plainly marked or tagged with UL labels, AWG size, voltage rating, insulation type, type of stranding, manufacturer's name, trade name, and month and year when manufactured.

3.0 CONSTRUCTION

3.1 GENERAL

3.1.1 All conductors shall be insulated and installed in raceways, cable trays, boxes, fixture or equipment enclosures unless specifically indicated otherwise on the Drawings.

3.1.2 Do not install conductors until raceway runs are completed with terminating enclosures installed and structural, drywall, masonry, concrete, or other work which may damage conductors is completed, except as otherwise approved by the City Engineer. Raceways shall be clean and dry prior to installation of conductors.

3.1.3 Mechanical devices or equipment for pulling conductors shall be identified and suitable for the purposes. Vehicles, cranes, etc., shall not be used. Use pulling means; including fish tape, cable, rope, and basket-weave wire/cable grips, which will not damage cables or raceway.

3.1.4 Group, tie wrap, and suitably identify the conductors of each system, where conductors of circuits with different electrical characteristics are installed in the same enclosure.

3.1.5 Conform control wiring to the wiring diagrams relevant to the manufacturer's wiring diagrams as necessary to control the equipment in the manner specified required.

3.1.6 Pull Conductors: Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

3.1.7 Wiring at Outlets: Install conductor at each outlet, with at least 6-inches of slack.

3.2 COLOR CODING. Required: For all branch circuit wiring, feeders, bonding and grounding conductors as follows:

480/277 Volt 3 Phase Wire Systems			
Phase A	Phase B	Phase C	Neutral
Brown	Orange	Yellow	White
208/120 Volt 3 Phase 4 Wire Systems			
Black	Red	Blue	White
240/120 Volt 3 Phase 4 Wire Systems			
Black	Red	Blue	White
120/240 Volt 1 Phase 3 Wire Systems			
Black	Red		White

3.2.1 Bonding or Grounding Conductors: Green or green with yellow stripe(s).

3.3.3 Do not use light gray or natural gray colors.

3.3.4 When a color is established it shall be maintained throughout the entire length of the circuit, except that switch loops between 3-way or 4-way switches may be different colors.

3.3.5 Color coding for conductors No. 6 AWG or smaller shall be accomplished by inherent insulation color; tags, paint tape or other marking shall not be used for color identification.

3.3.6 Mark each phase of leg in each panelboard with identifying tape.

3.4 TAGGING

3.4.1 General: Install identification markers on ungrounded conductors of all circuits, in switchboards, panelboards, pull, junction and outlet boxes, lighting fixtures, switches, receptacles and other terminating enclosures. Grounded circuit conductors shall have identification markers in switchboards, panelboards, and all enclosures where more than one circuit grounded circuit conductor is installed. Identification shall include switchboard, panelboard, or other source and circuit number. Tags shall be 3M Co. "Scotchcode" write-on tape or shall be pre-marked with self-adhesive wraparound cloth type EZ Code, Brady.

3.4.2 Tagging: Conductors shall be tagged in each junction box, pullbox, wirewy or auxiliary gutter and at each device, motor outlet, panelboard, switchboard or other conductor termination. Tag shall show feeder number, size, phase and origin.

3.5 SPLICES

3.5.1 Make splices for No. 8 AWG and smaller conductors with twist-on type pressure connectors suitable for the number and size of conductors. Connectors shall be Ideal Industries Inc., "Wingnut" or equal.

3.5.2 Make splices for No. 6 A.W.G. and larger conductors with bronze split-bolt or solderless compression type connectors requiring the use of a pressure tool. Connectors shall be wrapped with varnished cambric prior to taping, where tape is used as the insulating medium.

3.5.3 Make "pigtail" type splices at multiple conductor terminations for lighting fixtures, switches, receptacles, and other devices or outlets, to provide for connection of a single set of circuit conductors to the device or load. This requirement shall not apply to line and load conductors connected to GFCI type receptacles.

3.5.4 Install each feeder conductor without splice or joint, from equipment terminal to equipment terminal, except as specifically indicated otherwise on the Drawings.

3.5 MISCELLANEOUS (AS APPLICABLE)

3.5.1 Make all branch circuit and fixture joints for #10 AWG and smaller wire with UL approved connectors, listed for 600 volts. Provide Minnesota Mining and Manufacturing Co. insulated "Scotch locks", Ideal Co. "Wing-Nut", or T&B Burndy Co. "Piggy" connectors.

3.5.2 Make all branch circuit joints of #8 AWG and larger with screw pressure lugs, and insulate with electrical tape to 150% of the insulating value of the conductor insulation.

3.5.3 Tape all connections made with non-insulated type connectors with half-lapped, rubber-type tape, to 1-1/2 times the thickness of the conductor insulation, then cover with Scotch #33 tape.

3.5.4 Each circuit must correspond to the branch circuit number indicated on the panel schedule shown on the drawings except where departures are approved.

3.5.5 Neatly group or tape together wiring within equipment enclosures.

3.5.6 Where conductors in conduit pass through exterior walls, a sealing compound of moisture-resistant material shall be applied in the ends of the conduits to seal around the conductors.

3.5.7 Megger tests shall be taken on all feeder conductors and on all conductors for the lift station pump motors. Tests shall be made in presence of the City's representative and prior to connection of equipment. Written reports of results shall be submitted to the City Engineer. Conductors testing below manufacturer's standard shall be replaced.

1.0 MOTOR CONTROL CENTERS.

1.1 This Section includes indoor motor control centers (MCCs) for use on AC circuits rated 600 volts or less. Drawings and general provisions of the specifications apply to this Section. Review these documents for coordination with additional requirements and information that apply to work under this Section.

1.1 Related Sections:

Special Provisions
Basic Electrical Materials
Conduits and Raceways
Conductors 600V and Below
Grounding System

1.2 REFERENCES. The following documents form part of the Specifications to the extent stated. Where differences exist between codes and standards, the one affording the greatest protection shall apply. Unless otherwise noted, the edition of the referenced code or standard that is current at the time of the "date of the contract" for the Work shall be considered the effective code or standard for the duration of the project.

- NFPA – National Fire Protection Association
  - NFPA 70 National Electrical Code
  - NFPA 70E Standard for Electrical Safety in the Workplace

- NEMA – National Electrical Manufacturers Association
  - NEMA 250 Enclosures for Electrical Equipment
  - NEMA ICS 2 Industrial Control Devices, Controllers and Assemblies.
  - NEMA ICS 2.3 Instructions for Handling Installation, Operation and Maintenance of Motor Control Centers
  - NEMA KS1 Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Max.)
  - NEMA ATS Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems

- UL – Underwriters' Laboratories
  - UL 485 Motor Control Centers.
  - UL 489 Molded Case Circuit Breakers and Enclosures
  - UL 508 Industrial Control Equipment.

1.3 SUBMITTALS. Submit in accordance with General Conditions, Special Provisions and following guidance.

1.3.1 Shop Drawings: The Subcontractor shall submit for approval Shop Drawings prepared in accordance with approved schedule and as required by other sections of the Specifications. All submittals and shop drawings shall be reviewed and approved by the Engineer before procurement or fabrication of material and equipment.

- Submit 5 copies of Product Data and Shop Drawings for equipment and component devices. Include time–current curves of fuses, relays, and circuit breaker trip units.

- Include dimensional plans and elevations; conduit entrance locations and requirements; component and device lists and descriptions; and a three line diagram showing horizontal and vertical bus full-load and short-circuit ratings of the MCC. Include interconnecting wiring diagrams pertinent to the class and type specified for the motor control center, and a schematic diagram of each type of controller unit indicated.

- Manufacturer's Installation Instructions: Indicate application conditions and limitations of uses. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of the MCC.

1.3.2 Operation and Maintenance Data: Furnish 5 original copies and 1 compact disc of recommended maintenance procedures and intervals. Include spare parts data listing; source and current prices of replacement parts and supplies.

- Furnish 5 hardcopies and 1 compact disc of As-Built Drawings which include the elementary and connection diagram. Electronic drawing files shall be in AutoCAD 2012 format and Adobe pdf format.

- Furnish Time–Current curves of fuses, relays, circuit breaker trip units. Time–Current curves shall be first generation originals on full size 11 by 17 inches (280 by 432 mm) paper.

- List special tools and spare parts required for maintenance and repair.

- Name, address, and phone number of the service representative to be called in the event of equipment failure.

- Submit 5 copies of the warranty certificate.

- Any exceptions taken from the specification shall be submitted to the Engineer not less than 10 days prior to the opening of bids.

1.4 QUALITY ASSURANCE. Products shall be tested, approved and labeled/listed by Underwriters Laboratories, Inc., or by a nationally recognized testing laboratory (NRTL). Electrical equipment and materials shall be new and within one year of manufacture, complying with the latest codes and standards. No used, re-built, refurbished and/or re-manufactured electrical equipment and materials shall be furnished on City projects.

1.5 COORDINATION. It is the intent of these Specifications that the actual electrical service and motor control center be fully-integrated integrated with the controls and automation systems in a single cabinetry system, if and when applicable; that the cabinetry be uniform, symmetrical and designed as a single assembly; and compliant with NEC in all respects.

1.6 DELIVERY, STORAGE, AND HANDLING. Store in a clean, dry space and maintain factory wrapping. Do not deliver to the site until ready for placement and installation. Handle in accordance with manufacturer's written instructions and NEMA ICS 2.3. Lift only by lifting lugs or devices provided for the purpose. Handle carefully to avoid damage to motor control center internal components, enclosure, and finish.

1.7 WARRANTY. Provide one year minimum warranty period beginning at the date the equipment is energized after acceptance by the City. Submit five (5) copies of the warranty certificate to the City.

1.8 EXTRA MATERIALS. Furnish 4 spares of each type and rating of fuse and fusible devices required. Include 6 spares for each type of indicating lights. Provide 1 half-pint touch-up paint.

2.0 MATERIALS AND PRODUCTS

2.1 MANUFACTURERS. Only the following manufacturers shall be approved.

- Rockwell Allen-Bradley
- Schneider Square D
- ABB
- Siemens
- General Electric
- Eaton/Cutler-Hammer.

2.2 MOTOR CONTROL CENTER

2.2.1 Motor Control Center: NEMA ICS 2, Class I, Type B. Provide pressure type pull-apart blocks. Identify each terminal with a wire number corresponding to the shop drawing.

2.2.2 Ratings and Classifications:

- Voltage, Phases, Wires: 480V, 3-Phase, 3-Wire
- Frequency: 60 Hz
- Current I(Horizontal (Main) bus) 400 Amperes
- Short Circuit Rating 65 kAIC symmetrical.

2.2.3 Main Circuit Breaker: The MCC shall be provided with a Main Circuit Breaker with a solid state trip unit having the following trip functions

- Instantaneous
- Long time pickup
- Long time delay
- Short time pickup
- Short time delay
- I^2t feature
- Ground fault pickup
- Ground fault delay

2.2.4 Bus Work: Bus work shall be copper and sized for the continuous current ratings specified above. Provide a copper ground bus the entire length of control center, preferably in the bottom 6 inches of the structure and bonded to each enclosure section. Provide silver plated or tin plated contact surfaces on busses.

2.2.5 Configuration: Units front mounting only, accessible from the front only. Bus splice plates front accessible. Maximum overall length as shown on the drawings. Provide top and bottom horizontal wireways. Provide hinged vertical wireways, if and as required, with wire supports. Drawout units shall be in increments of 6 inches (150 mm) with a minimum size of 12 inches (300 mm). Maximum drawout units in a vertical section to be 6.

2.2.6 Enclosure. NEMA ICS 6, Type 1A (Gasketed). The MCC shall be full assembled and free-standing. Provide a welded steel framework, adequately braced and attached to a steel channel base, to meet the requirements of Seismic Zone 2. The enclosure shall be thoroughly cleaned, primed and painted in accordance with the manufacturer's standard finishing process. Exterior enclosure covers and doors shall be ANSI-61 gray. Enclosure interior and drawout assemblies shall be white.

2.2.7 Drawout Assembly: Provide removable combination starter compartments, interchangeable for different size starters, with barriers to completely enclose a drawout starter assembly. Provide insulating barriers with openings for stab connectors on starter units located on the starter side of the vertical bus. Provide insulated covers for unused drawout openings.

2.2.8 Metering. Provide electronic metering to indicate, as a minimum, the following values:

- Voltage: Line-to-Line and Line-to-Neutral
- Current: All Phases, neutral and Ground
- Power and Energy: kWH, kW Demand
- Power Factor
- Frequency
- Total Harmonic Distortion: Volts and Amperes

Electronic metering shall be provided with a communications module with a 10Base-T Ethernet and an industry standard RS-485 serial bus compatible with Modbus protocol. Potential, control power and current transformers shall be completely installed and wired to the power meter mounted in the incoming service cabinet. The electronic power meter shall be Square D PowerLogic ION7350 or higher, Siemens Model 9350 or higher, Power Measurement Limited Model 7350 or higher, or approved equal. The supplier shall obtain the written approval for substitution from the Engineer.

2.3 MOTOR CONTROLLERS. Coordinate the features of each motor controller with the ratings and characteristics of the supply circuit, the motor, the required control sequence, the duty cycle of the motor, drive, and load; the pilot devices; and the control circuit affecting controller functions. Provide controllers that are NEMA rated to suit the motor controlled. Position motor controllers within the MCC structure as shown on the drawings. Contacts shall open each ungrounded connection to the motor or load.

2.3.1 Provide combination motor control units for 2 each 60 HP sewage pump motors with space for a third (future) pump; and 1 each 5 HP sewage grinder, each with

- Molded case circuit breaker
- Vertically-oriented/operated disconnect switch handle
- 12-inch compartments, (vertically), nominal
- Unless required otherwise by the pump manufacturer, Class I Type B wiring

- Terminal blocks furnished for wireway for control circuit connections
- Pilot devices wired to terminal block by manufacturer
- Load wires connected directly on starter/contactor by Electrical Sub

2.3.2 Motor protection shall be provided by a solid state, microprocessor based overload and fault protection system. Overload protection shall consist of one current sensor located on each phase monitored by a microprocessor that yields a time current curve closely paralleling that of the motor heating damage boundary, accurate to 2 percent. Running overload protection shall be field selectable for the specific motor full load amperes within the starter range. Trip class of 10, 20, and 30 shall be field selectable and provide 10, 20 or 30 second delay at 6 times the full load running protection respectively.

2.3.3 Motor protection is to monitor current in each phase to provide phase loss and phase unbalance protection, such that if the unbalance on two phases is greater than 30 percent of the selected trip rating, a phase loss/unbalance trip occurs. Provide phase loss/unbalance protection which requires no time delay for reset.

2.3.4 Ground fault protection shall be provided and set at 20 percent of maximum continuous ampere rating and have a start delay of 20 seconds, and a run delay of one second to prevent nuisance tripping on starting.

2.3.5 The microprocessor shall measure control circuit voltage and prevent closing of the coil on low voltage (78 volts AC) and/or high voltage (135 volts AC) conditions that are outside the coil ratings.

2.3.6 Provide full voltage, non-reversing across-the-line, magnetic controller, except where another type is required.

2.3.7 Provide control power transformer integral with the controller where no other supply of 120 VAC control power to the controller is indicated. Provide control power transformer with adequate capacity to operate connected pilot, indicating and control devices, plus 100 percent spare capacity.

2.3.8 Combination motor controller shall include motor circuit protector type molded-case circuit breaker with magnetic-only trip element calibrated to coordinate the actual locked-rotor current at the connected motor and the motor controller overload relays. Provide circuit breakers that are factory assembled with the controller, interlocked with the unit cover or door, and arranged to disconnect the controller. Provide motor circuit protectors with field adjustable trip elements as specified above.

2.3.9 Communications: Each motor controller shall be capable of communications via a twisted-pair network.

2.3.10 Provide LED-type indicating pilot lights on combination motor control units:

Color	Label	Commentary
Green	RUN	Motor is running
Red	STOP	Motor is not running
Amber	CAUTION	Motor has voltage but is not running; denotes remote fault
HAND-OFF-AUTOMATIC		Operational Mode Selector Switch

"Green" denotes motor is running (voltage and amperage in the line). "Red" denotes motor is not running (voltage across the line but no current flow). Amber denotes fault in a remote device [such as a jammed sewage grinder or motor].

2.3.11 Spaces and blank compartments shall be fully bussed and equipped with guide rails or equivalent, ready for insertion of units. Spare units, if any, shall be of the type, size and ratings indicated and installed in compartments indicated “spare.”

2.4 OPTIONS AND FEATURES

2.4.1 Auxiliary Contacts: NEMA ICS 2, 2 each normally open and normally closed auxiliary contacts for each motor controller.

2.4.2 Cover Mounted Pilot Devices: NEMA ICS 2, standard duty oil tight type.

2.4.3 Pilot Device Contacts: NEMA ICS 2, Form Z, rated A150.

2.4.4 Indicating Lights: LED type. Two per starter. One red, one green, one amber.

2.4.5 Selector Switches: Rotary type, hand-off-auto (HOA).

2.4.6 Control Power Transformers: 120 volt secondary, in each motor starter. Provide fused primary and secondary, and bond unfused leg of secondary to enclosure.

2.4.7 Identification: Equip each starter cubicle door with engraved nameplate showing the circuit number of the motor controlled, the name, load and the horsepower of the motor. Nameplates shall be of a size to accommodate minimum one quarter-inch high letters. Use black background with white lettering.

2.4.8 Lockouts: Provide space for padlocking starters in the OFF position with at least two padlocks.

2.4.9 Distribution Panelboards: Meet the requirements of Section 16000. The configuration and ratings of the circuit breakers within the panelboard shall be as shown on the drawings and/or panel schedule.

3.0 CONSTRUCTION

3.1 FIELD INSTALLATION. Verify that equipment floor pad is level; pour concrete leveling pad as needed. Verify field measurements are as required by manufacturer. Verify that required utilities are available, in proper location and ready for use. Observe restrictions imposed by safety tags and locks. Install in accordance with manufacturer's instructions. Install safety labels to NEMA 260. Provide typed 8-1/2 by11-inch circuit directory (panel schedule) for the motor control center and associated panelboards.

3.2 FIELD QUALITY CONTROL

3.2.1 Tests shall be made in the presence of the Engineer or City Inspector. The application or interruption of power shall be programmed and directed in accordance with the approved permit, work tasks and safety compliance steps.

3.2.2 Comply with requirements of NETA Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems and the manufacturer's inspection, testing, calibration and start-up procedures. The manufacturer's technician or experienced and qualified electrician shall perform inspection, testing, calibration and start-up, with assistance. Schedule testing and start-up with at least 10 working days advance written notification.

3.2.3 Visual and Mechanical Inspection: Inspect for physical damage, proper alignment, anchorage, and grounding. Check proper installation and check correctly torqued connections of busswork with a calibrated torque wrench.

3.2.4 Perform insulation resistance test of motor control center buses, components, connecting supply feeder, and control circuits. Insulation resistance less than 100 megohms is not acceptable. Perform continuity tests of circuits.

3.2.5 For each motor controller, perform operational test and exercise of mechanical components and operable devices in accordance with manufacturer's instruction manual. Verify ratings and settings of overload relays, motor circuit protectors, and overcurrent protective devices.

3.2.6 The Subcontractor shall submit to the City Engineer 5 copies of test results, certified in writing, witnessed, signed and dated, immediately upon completion of work for review and acceptance by the City. An unsatisfactory condition revealed by these test results, or unsatisfactory methods of tests and/or testing apparatus and instruments, shall be corrected, re-tested and validated. The City Engineer reserves the right to require that the Electrical Subcontractor perform and repeat tests that are deemed necessary to complete or check the tests or the certified records at any time during the course of the work. The Subcontractor shall correct unsatisfactory portion of his work that is revealed by the tests or that may be due to progressive deterioration during this period, unless the item in question was a direct specification.

3.3 ACCEPTANCE AND ENERGIZATION. Final acceptance shall depend upon the satisfactory test results as performed in accordance with the manufacturer's instructions. After tests have been reviewed and approved by the City, energization may proceed. Upon energization test and record readings for proper voltages, correct (clockwise) phase rotation and phase sequence (A-B-C) for both incoming and outgoing feeder and branch circuits.

3.4 TRAINING. Conduct a minimum of 4 hours of training in operation and maintenance for up to 4 City technicians. The training session shall be conducted by a qualified manufacturer's technician, manufacturer's qualified representative or Senior Licensed Electrician with applicable experience approved by the Engineer. Schedule training with at least 5 working days advance notification.

1.0 WATER AND WASTEWATER FACILITIES GROUNDING SYSTEMS

1.1 THE REQUIREMENT. The CONTRACTOR shall furnish all tools, equipment, materials, and supplies and shall perform all labor required to complete the work as indicated on the Drawings and specified herein.

1.2 RELATED WORK SPECIFIED ELSEWHERE. The work of the following Divisions applies to the work of this Section. Other Divisions and Sections of the specifications not referenced below shall also apply to the extent required for proper performance of this work. Materials, equipment and devices furnished and installed under Divisions with raceway and electrical conductors furnished, installed, and connected.

1.3 REFERENCED SPECIFICATIONS, CODES AND STANDARDS.

1.3.1 All work specified herein shall conform to or exceed the applicable requirements of the referenced portions of the following publications to the extent that the provisions thereof are not in conflict with other provisions of these specifications.

1.3.2 Comply with the current provisions of the following Codes and Standards.

- NEC National Electrical Code, latest adopted edition.
- ANSI/UL 467 Safety Standard for Grounding and Bonding Equipment.
- IEEE 142 Grounding of Industrial and Commercial Power Systems

1.3.3 All l equipment furnished by the CONTRACTOR shall be listed by and shall bear the label of Underwriters' Laboratories, Incorporated, (UL) or of an independent testing laboratory acceptable to the City Engineer.

1.4 CONTRACTOR SUBMITTALS

1.4.2 Submittals shall conform to the requirements of Section 16160 Conductors and additional requirements specified herein. Submittals shall be made for, but not be limited to the following:

- Catalog literature for all products.
- Certified copies of ground test results.
- Field test procedures including lists of test equipment to be used.

1.5 QUALITY ASSURANCE. Quality assurance shall be in accordance with NEC.

2.0 MATERIALS AND PRODUCTS

2.1 GROUND RODS. Provide copper-clad steel ground rods not less than 3/4 inch in diameter, 10-feet long driven full length into the earth. Special requirements shall be as shown and as specified herein.

2.2 GROUND CONDUCTORS. Provide grounding conductors of the size shown and the type specified in Section 16160, "Conductors" or as shown on the drawings.

2.3 GROUND CONNECTIONS. For both below grade and above grade connections, provide exothermic-welded connectors.

3.0 CONSTRUCTION

3.1 GENERAL

3.1.1 UnlessExcept where specifically indicated otherwise, ground all exposed non-current carrying metallic parts of electrical equipment, raceway systems, and the neutral of all wiring systems in strict accordance with the state, and other applicable laws and regulations.

3.1.2 Wherever it is decided to run individual equipment grounding wires, rather than rely on raceways as return paths for fault current. Such a grounding wire should be included on all medium voltage circuits.

- Where grounding conductors are shown, bond the wires to metallic enclosures at each end and to all intermediate metallic enclosures. Connect grounding conductors to all grounding bushings on raceways. Where any equipment contains a ground bus, extend and connect grounding conductors to that bus. Connect the enclosure of the equipment containing the ground bus to that bus. Run ground conductors inside conduits enclosing the power conductors.

- Ground connection to equipment and ground buses shall be by copper ground lugs or clamps. Connections to enclosures not provided with ground buses or ground terminals shall be by clamp type lugs added under permanent assembly bolts or under new bolts drilled and added through enclosures other than explosion proof, or by grounding locknuts or bushings. Explosion proof enclosures not provided with any of the above grounding means shall be grounded by the addition of an adjacent junction box with a ground lug. Ground cable connections to anchor bolts, against gaskets, paint, or varnish, or on bolts holding removable access covers will not be permitted.
- Install ground rods as shown on the drawings. Provide additional ground rods if and as necessary so sufficient ground rods in addition to code required grounding so that resistance to ground as tested by standard methods does not exceed 1 ohm. If more than 1 rod is required, install rods at least 3-feet apart.

3.1.3 Ground shields of any shielded power cable at each splice or termination in accordance with recommendations of the splice or termination manufacturer. Ground shields of any control cables likewisein accordance with the details shown.

3.1.4 Ground metal sheathing and any exposed metal vertical structural elements of buildings. Ground metal fence of the site as shown on the drawingss enclosing electrical equipment. Bond any metal equipment platforms which support electrical equipment to that equipment. Provide good electrical contact between metal frames and railings supporting pushbutton stations, receptacles, instrument cabinets, etc., and raceways carrying circuits to these devices.

3.1.5 Bond neutrals of transformers within existing facilities or buildings to the system ground network if present or to any additional indicated grounding electrodes.

3.1.6 Ground cable penetrations through building exterior walls shall enter within 3 feet below finish grade and shall be prepared with a water stop. Unless otherwise indicated, the water stop shall include filling the space between the strands with solder and soldering a 12-inch copper disc over the cable. The ground shall be in earth and, unless specified elsewhere, tied to site fencing of the building, station or facility as shown on the drawings as far from the structure as the excavation permits but not closer than 6 inches.

3.1.7 The main grounding conductor when exposed within the station, facilty or a building shall be copper bar supported with suitable spacers at ½ to 1 inch from the structure. Unless otherwise indicated on the drawings, the ground bus shall not be smaller than 1/4-inch by 1 inch rectangular.

3.1.8 Lighting fixtures and convenience outlets shall be grounded with a separate ground conductor.

3.1.9 The grounding system shall be bonded to the lift station station piping by connection to the first flange inside the valve vault on either a suction or discharge pipe which will form a good ground connection. The connection shall be made with a copper bar or strap by drilling and tapping the flange and providing a bolted connection or by exothermic weld.

3.1.10 Ground conductors on equipment shall be formed to the contour of the equipment and firmly supported. All ground connection hardware, bolts, and nuts shall be high strength, high conductivity copper alloy. Ground cables with encased underground conduit banks as indicated on the drawings.

3.1.11 Ground cables in underground circuits shall be bonded with main ground cables in each maintenance hole and handhold. Maintenance hole hardware and cover shall be effectively grounded. Liquid tight flexible conduits shall be provided with separate equipment grounding conductors. The equipment grounding conductor shall be bonded to an approved grounding bushing and terminal lug. The grounding conductor can be installed outside the conduit if the required size is greater than No. 10. Exposed splices and connections for bare copper conductors and buses shall be protected by wrapping with heat shrink tape or covering.

3.2 GROUNDING CONNECTIONS

3.2.1 Unless shown otherwise, make connections of grounding conductors to ground rods at the upper end of the rod with the end of the rod and the connection point immediately below finished grade. Make connections of sections of outdoor ground mats (counterpoise) for substations or other equipment underground. Make connections of other grounding conductors generally accessible. In manholes, install ground rods with ends 4 to 6-inches above the floor with connections of grounding conductors fully visible and accessible.

3.2.2 When making exothermic welds, wire brush or file the point of contact to a bare metal surface. Use exothermic welding cartridges and molds in accordance with the manufacturer's recommendations. After welds have been made and cooled, brush slag from the weld area and thoroughly clean the joint.

3.2.2 Use connectors of proper size for conductors and ground rods specified. Use connector manufacturer's compression tool. Notify the ENGINEER and the INSPECTOR prior to backfilling any ground connections.

3.3 FIELD TESTS. Test for continuity throughout the installed system.

1.0 EMERGENCY STANDBY GENERATOR SYSTEM

1.1 SCOPE. This section covers the work necessary to provide and complete the standby emergency power generating system.

1.2 REQUIREMENT. The CONTRACTOR shall furnish all tools, equipment, materials, and supplies and shall perform all labor required to complete the work as indicated on the Drawings and specified herein. The WORK of the following Sections and Division applies to the WORK of this Section. Other Sections of the Specifications, not referenced below, shall also apply to the extent required for proper performance of this WORK.

1.3 REFERENCE SPECIFICATIONS, CODES AND STANDARDS. All work specified herein shall conform to or exceed the applicable requirements of the NEC and the Ardmore City Electrical Code, latest adopted edition. All equipment furnished by the CONTRACTOR shall be listed by and shall bear the label of Underwriters' Laboratories, Incorporated, (UL) or of an independent testing laboratory acceptable to the City Engineer.

1.4 CONTRACTOR SUBMITTALS. Submittals shall be made in accordance with these specifications and the Special Specifications for the project.

1.5 QUALITY ASSURANCE. Generator shall be manufactured and supported by nationally-recognized, name brand, concern, the principal business of which is generator systems manufacturing and assembly, or otherwise acceptable to the Engineer.

1.5.2 Guarantee/Warranty: The manufacturer shall provide its standard commercially available warranty for a period of not less than 5 years from date of delivery to the site, that equipment and systems will be free from defects in material and workmanship. Contractor and generator vendor/supplier shall certify that the generator has been properly installed and field-tested in accordance with manufacturer's instruction manuals.

2.0 MATERIALS AND PRODUCTS

2.1 General: The general design of the engines furnished shall be the standards of the various manufacturers, except where these differ from the requirements of these Specifications. The design shall be such as to provide adequate strength of all parts for the specified duty. The complete engine generator unit shall be mounted on a common steel sub base.

2..2 Engine: The engine shall be the full four-cycle diesel type suitable for a continuous output of the specified kilowatt rating when driving a synchronous generator at a speed not exceeding 1800 rpm. Horsepower ratings shall be adequate for 1000 feet amsl.

2.2.1 Starting System: The engine shall be equipped with automatic starting by a 12-volt or a 24-volt battery driven starter acting in response to the automatic starting panel, hereinafter specified. Batteries shall be a minimum 200 amp-hour capacity and the 24-volt system may be either one 24-volt or two 12-volt batteries in series. The batteries shall be housed in an acid-resistant frame, or box, which shall be mounted on a concrete pad adjacent to the engine. Location of the battery container shall not interfere with maintenance and inspection of the engine.

2.2.2 Fuel and Governing System:A fuel oil transfer pump driven off the engine shall be provided to pump the fuel from the underground storage tank to the engine. An engine mounted day tank shall be provided A fuel oil filter with replaceable element shall be provided. Fuel connections to the engine shall be with flexible hose suitable for the purpose at least 18-inches long.The governor shall be either mechanical or hydraulic and shall provide not more than 5 percent regulation over the speed range. Governor adjustment shall be by means of an external vernier scale. An overspeed trip shall be provided.2.2.3 Cooling System:he jacket water cooling system shall consist of an engine mounted radiator with jacket water pump, fan, assembly, and fan guard. The radiator shall be fitted with a duct flange outlet.Provide an engine thermostat to regulate engine water temperature as recommended by the manufacturer. Provide a high-coolant temperature device to shut down the engine through the engine control panel when the engine temperature exceeds 200 degrees F. The engine cooling system shall be filled with a mixture of water and permanent type antifreeze to protect the system to a temperature of -10degrees F.

2.2.4 Lubricating System:The engine lubricating system shall be full-pressure type with a device to shut down the engine through the engine control panel on low oil pressure. Provide an oil filter with replaceable element and a bayonet type oil level stick. Provide a valved oil drain extension as shown.Lubrication oil shall be cooled by a water-cooledheat exchanger utilizing jacket water.2.2.5 Exhaust System. The muffler shall be rated for residential silencing. Exhaust pipe shall be Schedule 40 steel pipe conforming to ASTM A 53. Fittings shall be screwed cast ironSchedule 40 butt welding type. Connection of the exhaust pipe to the engine shall be by means of a flanged, flexible, corrugated, stainless steel pipe especially suited for diesel exhaust service. Flexible length shall be 18 inches.

Air Intake System: The engine air intake shall be equipped with a dry type air cleaner with filter service indicator2.2.7 Engine Instrumentation: Instrumentation to be provided shall include an oil pressure gauge, coolant temperature gauge, tachometer, fuel pressure gauge, and running time meter. These gages shall be installed on the engine starting panel as described under Starting Control Panel.

2.3 GENERATOR.

2.3.1 Requirement. Generator shall be capable of starting the specified motor or motors of the specific horsepower for stepped motor loads with an additional 25kW of ancillary loads with a voltage dip not to exceed 20%. The size of the generator, the number of motors to be served, and the starting sequence of the motors is specified in the Special Specifications or as directed by the Engineer.

2.3.2 Design and Operating Parameters.

- Diesel Generator Nominal _____ kW
- National Standard UL2200
- Basic Standard NFPA 110 Compliant
- Nominal Full Load Speed 1800 rpm
- Output Voltage 277/480/3-phase
- Output Breaker 4W with _____ Amp 3P 100% rated output breaker
- Battery Charger 10 Amp
- Block Heater -20 Deg F

- Base Tank 48 Hour UL142
- Enclosure 75dBA @ 25 ft
- Remote annunciator Position in control room
- Battery Charger Circuit 120V 20A
- Block Heater Circuit 120V 20A
- Start Wire Conduit 3/4-inch
- Remote Annunciator 2-pair shielded cable

2.3.4 The complete engine generator set, including the instrument panel, shall be given a factory-applied primer and two finish coats of the manufacturer's standard heat-resistant engine paint. The color shall be as selected during submittal phase.

2.3.5 Generator Manufacturers: Taylor Power Systems, MTU Onsite Energy, Kohler, Generac or equal

- 5 year comprehensive warranty

- Generator supplier must furnish complete system with startup by factory trained technician and full training of City personnel

- Contractor shall be responsible to install a complete working system to the satisfaction of the City

2.3.6 Not used. The generator shall be single-bearing, brushless synchronous type, suitable for direct connection to the engine. The generator shall have the following electrical characteristics:

- The generator shall be supplied with a voltage level control to provide an adjustable output voltage of +5 percent. The voltage control device shall be mounted on the engine starting panel.

2.3.7 Subbase and Vibration Isolators.he engine and generator shall be mounted on a common steel frame sufficiently rigid to prevent deflection between vibration isolators. The engine generator shall be mounted on Korfund Series L or equal vibration isolators. Vibration isolators shall be sized by the isolator manufacturer and shall be such to limit the maximum vibration transmissibility to 10 percent.

2.3.8 Torsional Vibration. The complete engine generator set shall be so designed, constructed, and installed as to be free from objectionable vibration in any mode.

2.4 AUTOMATIC LOAD TRANSFER CONTROL

2.4.1 The engine generator set shall be started and stopped in response to a power failure indicating contact in the automatic transfer switch. Provide a manual switch within the panel to simulate a power failure for test purposes. The starting control shall be provided with an adjustable timer to permit delay of engine starting for any period of time up to 5 minutes after power failure occurs. The engine shall be arranged so as to permit engine operation for an adjustable period of up to 15 minutes after station power has been re-established.

2.4.2 TThe automatic transfer switch shall be three-pole for a normal utility source of 480 volts, 3-phase, 60-Hz, and emergency engine generator source of 480 volts, 3-phase, 60-Hz. The switch shall automatically transfer from the normal to emergency source when any phase of the normal source drops below 70 percent and the emergency source is at 90 percent of rated voltage and frequency. Retransfer shall occur when all phases of the normal source are 90 percent or more of rated voltage for a time adjustable from 2 to 120 seconds. A 115-volt, 5-amp auxiliary contact shall be provided to signal the engine starting equipment upon the loss of the normal power source.

2.4.3 The transfer switch shall be rated 3-pole of the amperage shown on the plans or called for in the special specificatons, service entrance rated NEMA 3R by ASCO, GE, Zenith, Lake Shore, or from generator supplier.

2.4.4 Shall be mechanically held and electrically operated. The switch shall be constructed to prevent a neutral position upon the failure or malfunction of any part or device. Operating current for transfer shall be obtained from the source to which the load is to be transferred.

2.4.5 All of the above equipment shall be installed in a NEMA 4X type gasketed enclosure suitable for wall mounting. All switches, indicating lights, and pushbuttons shall be accessible with the door closed.

2.5 FUEL STORAGE. Provide fuel tank of the size sufficient to power the generator for full-load, full-run-time of 24 hours, as specified in the special specifications. Provide OPW quick disconnect to match City standard, to be specified.

2.14 SPECIAL TOOLS AND SPARE PARTS. Provide a set of specialty tools necessary for routine maintenance of the equipment. Include hydrometer and two-pronged battery voltmeter.

2.15 SPARE PARTSThe following spare parts shall be furnished:

- 3 Sets fuel oil filter elements and gaskets

- 3 Lubricating oil filter elements and gaskets
- 1 Air cleaner filter element
- 2 Sets packing for each auxiliary pump
- 2 Sets V-belts for fan and pump drives

3.0 CONSTRUCTION

3.1 ENGINE GENERATOR INSTALLATION

3.1.1 Locate the generator on a concrete pad as shown on the plans. Adjust size of pad in the field as necessary to accommodate the generator and provide 360 degree access by maintenance personnel.3.1.2 Generator shall be leveled and placed on vibration isolators in accordance with the manufacturerThe engine generator shall be leveled and placed on the vibration isolators in strict accordance with the isolator manufacturer's recommendations.

3.1.2 All surfaces damaged during shipment shall be repaired to "like-new" condition; touch-up paint and finishes after installation.

3.2 TESTS. Perform, as a minimum, the following tests and demonstrations for the City Engineer and Inspector.

- Run generator unloaded for 1 hour to check rpm, temperature rise, cooling system, fuel flow, fuel usage, and vibration.

- Test The engine generator unit shall be tested full load transfer with coordination starting of all equipment. Start lead motor followed by second motor. Observe transfer, second motor start-up, performance, output an voltage drops.

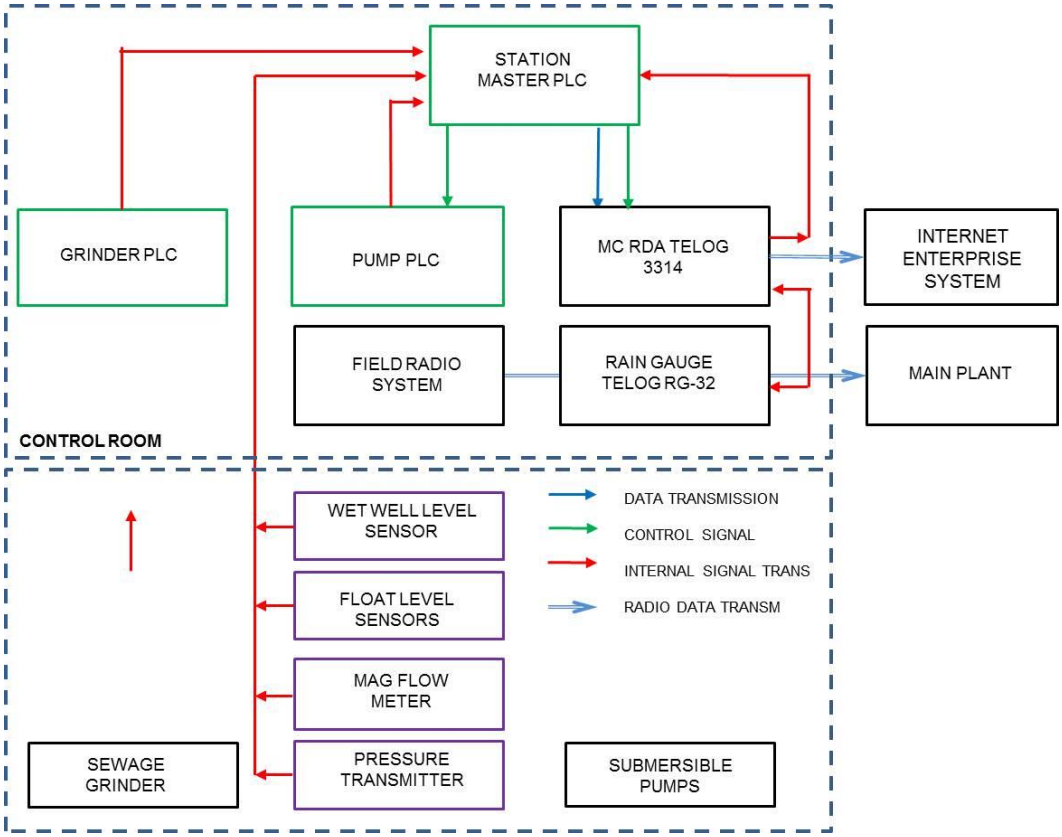
SECTION 9 PROCESS SYSTEMS
SUBSECTION 3 AUTOMATION AND CONTROLS

1.0 STATION CONTROL SYSTEM.

1.1 GENERAL. The purpose of this section is to provide guidance in the configuration of the overall Supervisory Control and Data Acquisition system to be deployed for the project. Guidance and specification is applicable to booster pumps stations, lift station or motor centers situated at City utility locations.

1.1.1 The primary control of the lift station is to be provided by a "Station Master PLC" to be located in the motor control center in the existing or new station. The secondary control system shall be by the PLC provided by the motor or pump manufacturer. In nominal and routine service, the pumping stations shall operate under the control of the Pump PLC as determined by the level in the reservoir, feed line, clearwell, or wet well using a standard mercury float switch system. The Station Master PLC shall be programmed so that the Operators may adjust station response and run times irrespective of the source levels. [In general, the need to override the Pump PLC could occur when flows from the souce are quite high such as during a wet weather event.]

1.1.2 Control Scheme. The following schematic depicts the relationship of the various control and data acquisition components.



1.1.3 Lift Station Monitoring. The primary means of lift station monitoring and the acquisition of data shall be by means of Telog multi-channel data recorder. A secondary system shall be by field radio (the current system). The telemetry system shall provide communications between the lift station and the Main Water Plant, Wastewater Treatment Plant or other designated control nodes ["central facility"] via cell phone and field radio. All field equipment furnished under this Section shall be installed at the locations as specified or shown on the Contract Documents. The equipment furnished for the Central Facility will be installed so as to be fully-compatible with existing radio system.

1.1.4 Scope of Work. The Contractor shall furnish, install, program and commission all control, data acquisition and monitoring subsystems including programmable logic controllers (PLCs), flow meter, pressure transmitter, level indicators, transducing, indicating, telemetering, recording, and alarm equipment together with remote cabinets, shown on the drawings and specified herein. The telemetering equipment shall perform the functions as shown on the functional diagrams and shall meet the requirements of the specifications. All equipment shall be as specified, no exceptions taken.

1.1.5 Related Work Specified Elsewhere. Electrical work specified hereunder shall conform to the requirements of this Section and the applicable requirements of the Section entitled "Electrical General Provisions.".

1.1.6 Reference Specifications, Codes, and Standards. Without limiting the generality of other requirements of these specifications, all work specified herein shall conform to or exceed the applicable requirements of the referenced documents to the extent that the requirements therein are not in conflict with the provisions of this Section; provided that where such documents have

been adopted as a code or ordinance by the public agency having jurisdiction, such code or ordinance shall take precedence. The equipment, materials, installation, and other work shall conform to all applicable regulations, standards, specifications and codes which are current as of the date of the final inspection for this Contract, including, but not limited to, those which are established by the following sources:

- Instrument Society of America (ISA)
- National Electrical Manufacturers Association (NEMA)
- Occupational Safety and Health Administration (OSHA)
- American National Standards Institute (ANSI)
- National Fire Protection Association (NFPA)
- Institute of Electrical and Electronic Engineers (IEEE)
- National Electrical Code (NEC)
- Local power and telephone companies
- Local authorities having jurisdiction over the work

Where the requirements set forth in these specifications or on the drawings are greater or more rigid than the mandatory requirements referenced above, the applicable specifications or drawings shall govern. In the case of conflict between any mandatory requirements and specifications or drawings, the mandatory requirements shall be followed in each case, but only after submitting such proposed changes to the Engineer for approval. Nothing contained in these specifications or shown on the drawings will be so construed to conflict with any national, state, municipal, or local laws or regulations governing the installation of work specified herein, and all such acts, ordinances, and regulations, including the National Electrical Code, are hereby incorporated and made a part of these specifications. All such requirements will be satisfied by the Contractor at no additional expense to the City.

1.1.7 Contractor Submittals

- Shop Drawings: It is incumbent upon the Contractor to coordinate the work specified in these Sections so that a complete instrumentation, computer, and control system for the facility will be provided and will be supported by accurate shop and record drawings including an electronic version in AutoCad, Landdesk Version 2005. Interface between existing instruments, existing control panels, motor control centers, starters, control valves, flowmeters, chemical feeders, and other equipment related to the instrumentation, control, and SCADA system shall be included in the shop drawing submittal.

- In these Contract Documents all systems, meters, instruments, and other elements are represented schematically and are designated by numbers, as derived from criteria in Instrument Society of America Standard ANSI/ISA S5.1. The nomenclature and numbers designated herein and on the drawings shall be employed exclusively throughout shop drawings, data sheets, and similar materials. Any other symbols, designations, and nomenclature unique to the manufacturer's standard methods shall not replace those prescribed above, used herein, and on the drawings.

- Should an error be found in a shop drawing during installation or start-up of equipment, the correction, including any field changes found necessary, shall be noted on the drawing and submitted finally "as-built" prior to acceptance of the project.

- Analog and SCADA System Hardware: This submittal shall be included in a singular, all-inclusive submittal which shall include but not be limited to:

    - A complete index appearing in the front of each bound submittal volume. System groups shall be separated by labeled tags.

    - A complete system block diagram.

    - Loop Diagrams: Drawings showing definitive diagrams for every instrumentation loop system: These diagrams shall show and identify each component of each loop or system using method, legend, and symbols from ANSI/ISA S5.4, extending the format of ANSI/ISA S5.1 The loop diagram shall also show the spare loops and/or spare I/O.

    - Loop description and/or facility operations descriptions.

    - Installation, mounting, and anchoring details for all components and assemblies, including access requirements and conduit connection or entry details.

    - Panel wiring and/or diagrams shall be prepared and the field wiring integrated. They shall include the Name of panel, Wiring and piping sizes and types, terminal strip numbers and electrical control schematics in accordance with ANSI standards

- Field wiring and piping diagrams shall be prepared and be integrated with the panel wiring diagram. They shall include the following information: Wiring and piping sizes and types, Conduits in which wiring is to be located, Panel (e.g. RTUs, etc.) termination strip numbers, and Location, function name, and manufacturer's designation of items to which wiring and piping are connected

- Drawings showing schematic diagrams for control circuits. Complete details on the circuit interrelationship of all devices within and outside each Control Panel shall be submitted using schematic control diagrams. The diagrams shall show numbered terminals on components together with the unique number of the wire to be connected to each terminal. The diagram shall also show terminal assignments from all primary measurement devices, such as flowmeters, and to all final control devices, such as samplers, pumps, valves, and chemical feeders.

- Interface with the existing control and monitoring system. This shall include any and all modifications made to existing measurement and control circuits, equipment, and wiring. It is the responsibility of the System Supplier to ascertain actual field conditions of the existing circuits, equipment, and wiring.

- Complete and detailed bills of materials: A bill of material list, including quantity, description, manufacturer, and part number, shall be submitted for each field- mounted device or assembly, cabinet assemblies and subassemblies as well as for the central computer system. Bills of material shall include all items within an enclosure.

- Data sheets for each component, together with a technical product brochure of bulletin.

The data sheets shall show:

- Component functional description used herein and on the drawings;
- Manufacturer's model number or other product designation;
- Project tag number used herein and on the drawings;
- Requirements for electrical supply (if any);
- Materials of construction;
- Special requirements or features, for ambient operating conditions;
- Features and options which are furnished.

- A separate technical brochure or bulletin shall be included with each instrument data sheet. The data sheets shall be indexed in the submittal by systems or loops, as a separate group for each system or loop. If, within a single system or loop, a single instrument is employed more than once, one data sheet with one brochure or bulletin shall include a list of tag numbers for which it applies. Special options and features which are furnished shall be identified.

- Calibration, adjustment, and test details for all components and systems.

- A list of recommended spare parts covering items which are furnished under this Contract with the name, address, and phone number of the manufacturer and manufacturer's local service representative or distributor of these parts.

- Technical Manuals: Three (3) final sets of technical manuals shall be supplied for the Owner in accordance with the Section entitled "Contractor Submittals," as a condition of acceptance of the project. Each set shall consist of one or more volumes, each of which shall be bound in a standard size, three-ring, looseleaf, vinyl plastic, hard-cover binder suitable for bookshelf storage. Binder ring size shall not exceed two inches.

- In addition to updated shop drawing information reflecting actual existing conditions, each set of technical manuals shall include installation, connection, operating, calibration, set points (e.g. pressure, pump control, time delays, etc.) adjustment, test, troubleshooting, maintenance, and overhaul instructions in complete detail. This shall provide the Owner with comprehensive information on all systems and components to enable operation, service, maintenance, and repair. Exploded or other detailed views of all instruments, assemblies, and accessory components shall be included together with a complete list of parts and ordering instructions.

- Spare Parts List: The Technical Manual shall also include a list of recommended spare parts for all the equipment furnished under this Section. After final system acceptance, the list shall be annotated to indicate which items, if any, and quantity are furnished as part of this Contract. The list shall also be furnished in accordance with the section entitled "Contractor Submittals."

1.1.8 Quality Assurance.

- Accuracy. Unless otherwise specified, each individual instrument shall have a minimum accuracy of +0.5 percent of full scale and a minimum repeatability of +0.25 percent of full scale.

- Installation Supervision: The System Supplier shall furnish services and technical information as necessary to ensure that the instrumentation and SCADA system equipment is installed in a proper and satisfactory manner. These services shall include, but not be limited to, providing the installing contractor with information and direction prior to commencement of the installation work, periodic inspections during the construction period, answering of all questions regarding the installation and hook-up, and a complete check of the completed installation to insure that it is in conformance with the requirements of the equipment manufacturer and the Contract Documents.

- Field Tests. The Contractor shall perform all necessary test to verify that the individual components as well as the Station overall performs in the field as specified in order to demonstrate compliance with the Contract Documents.

1.1.9 Storage and Handling. All equipment and materials delivered to the job site shall be stored in a location which will not interfere with the operations of other contractors or the Owner. Storage and handling will be performed in a manner that will afford maximum protection to the equipment and the materials. It is the Contractor's responsibility to assure proper handling and on-site storage of instrumentation and control equipment in accordance with the System Supplier's recommendations.

1.1.10 Environmental Conditions. The project site is a sewage lift station subject to weather extremes, humidity and odorific fluids. The instrumentation, controls, and SCADA systems shall be designed and constructed for satisfactory operation and long, low maintenance service under the following environmental conditions:

- Central Computer System:

    - Temperature range: 10° through 40° Celsius (50° through 104° Fahrenheit)
    - Thermal shock: 1.0° F per minute maximum
    - Relative humidity: 20% through 80% (non-condensing)

- Remote Site Equipment:

    - Ambient temperature range: 0 through 140° Fahrenheit
    - Thermal shock: 1.8° F per minute maximum.
    - Relative humidity: 100% maximum

1.1.11 Service Requirements. If required for troubleshooting, the Contractor shall provide jobsite visits and services of a manufacturer's technical field representative for calibration, testing, and startup of the following items.

- Level Transmitter
- Pressure Transmitter
- Flow Meter
- Rain Gauge

Field representatives or technicians shall supervise installation and connection of all instruments, elements, and components feeders, make all necessary adjustments, calibrations, and tests, and instruct operating and maintenance personnel on the instrumentation. This time

shall be in addition to whatever time is required for other facets of work at the site and shall be scheduled during normal working days and hours.

1.1.12 Guarantee

- The Contractor shall guarantee the performance and the hardware of all the instrumentation, control, telemetry, and SCADA equipment, as specified herein, for a period of one year following the date of completion and formal acceptance of the Work as specified under the General Conditions of these specifications. To fulfill this obligation, the Contractor shall utilize technical service personnel designated by the System Supplier to which the Contractor originally assigned project responsibility for instrumentation. Services shall be performed within three calendar days after notification by the Owner.

- Equipment and materials which do not achieve design requirements after installation shall be replaced or modified by the System Supplier to attain compliance, at no additional cost to the Owner. Following replacement or modification, the Contractor shall retest the system and perform any additional procedures needed to place the completed system in satisfactory operation and attain design compliance approval from the Owner.

- All parts, material (excluding consumables), labor, travel, subsistence, or other expenses incurred in providing all the services and service visits during the one year warranty period shall be borne by the System Supplier under the guarantee.

- The warranty period shall start when the work has been completed and accepted.

2.0 MATERIALS AND PRODUCTS

2.1 Clearwell, Wet Well or Station Source Measurement System. The primary level sensor system shall be a floating mercury level switch provided by the pump manufacturer. The Engineer will specify and the contractor will provide a secondary Level Measurement System, Capacitance/Admittance. The level measurement system shall consist of a sensing wire, an electronic transmitter, and interconnecting signal cable.

- The transmitter shall be a solid state unit with 4-20 mA output with a maximum load resistance of 650 ohms at 24 VDC.

- The transmitter shall have span-adjustable switches, non-interacting zero, and span fine tuning adjustments, transient (lightning/surge) protection and a selectable time delay for response output.

- The sensing wire shall be 5/32-inch OD, flexible polypropylene covered cable, have spacers every four feet, have stainless steel weight on the end, and have a flexible PVC boot at the top.

- The cable length shall be of sufficient length to run from the wet well to the Control Building with slack for internal routing.

- The transmitter shall be mounted at the top of the wet well in a weather-proof conduit housing with ¾ NPT connections for the sensing wire/flexible boot and a ¾ NPT connection for the 4-20 mA signal cable.

- The well level measurement system shall be powered by an external 24 VDC power supply and shall be a Drexelbrook or Sigma Controls, Inc. liquid level pressure probe, no substitutions.

2.2 Pressure Transmitters: Pressure transmitters shall be two-wire devices with the following features:

- Continuously adjustable span, zero and dampening adjustmens;
- integral indicator scaled in engineering units,
- Solid state circuitry with 4-20 mA output.
- Accuracy shall be no greater than +0.25 percent of span.
- Process wetted materials shall be 316 stainless steel.
- Body material shall be 316 stainless steel.
- Process connections shall be ½-inch NPT.
- Pressure transmitter shall be Rosemount Model 3051, or equal.

2.3 Flowmeter Transmitter: Flowmeter shall be McCrometer Brand. No substitutions.

3.0 CONSTRUCTION

3.1 Installation

3.1.1 General: Under the supervision of the System Supplier and in accordance with the manufacturer's instructions, all systems specified in the Contract Documents shall be installed, connected, calibrated, and tested; and, in coordination with the Owner, shall be started to place the system in operation. This shall include final calibration in concert with equipment specified elsewhere in these Contract Documents.

3.1.2 Nothing in this part of the specifications shall be construed as requiring the Contractor to utilize personnel supplied by its designated System Supplier organization or any division thereof, to accomplish the physical installation of any elements, instruments, accessories, or assemblies specified herein. However, the Contractor shall employ installers who are skilled and experienced in the installation and connection of all elements, instruments, accessories, and assemblies. Electrical work shall be performed as specified in these or the special specification applicable to the work.

3.1.3 The locations of equipment are approximate, unless dimensioned. The exact locations and routing of wiring and cables shall be governed by structural conditions and physical interferences and by the location of electrical terminations on equipment. Where job conditions require reasonable changes in approximate locations and arrangements, the Contractor shall make such changes without extra cost to the City.

3.1.4 All equipment shall be located and installed so that it will be readily accessible for operation and maintenance. The City reserves the right to require minor changes in location of equipment prior to roughing in without incurring any additional costs or charges.

3.1.5 The Contractor and System Supplier shall review the existing site conditions and examine all shop drawings for the various items of equipment in order to determine exact routing and final terminations for all wiring and cables.

3.1.6 Installation and Connection: The Contractor shall install and connect all field-mounted components and assemblies under the criteria imposed by these specifications and the System Supplier. The installation personnel shall be provided with a final reviewed copy of the shop drawings and data.

3.1.7 In building interior locations, conduits shall be surface-mounted on walls or ceilings wherever possible, and run parallel to building lines. Conduits shall not be routed on floors in areas subject to foot traffic. In exterior locations conduit shall be routed below grade. Where concrete or asphalt slabs exist, they shall be sawcut, conduits installed, and the cut repaired to original condition. Exposed conduits and/or raceway shall be installed perpendicular or parallel to building lines.

3.1.8 Signal and low voltage wiring shall be run separately from power and 120-volt control wiring. All analog signal loops shall be fused.

3.1.9 Bends shall be formed with proper tool and to uniform radii and shall be made without deforming or thinning the walls of the tubing. Plastic clips shall be used to hold individual plastic tubes parallel. Ends of tubing shall be square-cut and cleaned before being inserted in the fittings. Bulkhead fittings shall be provided at all panels requiring pipe and/or tubing entries.

3.1.10 The Contractor shall have a technical field representative of the System Supplier instruct installation personnel on any and all installation requirements; thereafter, the technical field representative shall be readily available by telephone to answer questions and supply clarification when needed by the installation personnel.

3.1.11 Final Checks: After all installation and connection work has been completed, the technical field representative shall check it all for correctness, verifying polarity of electric power and signal connections, and all other similar details. The technical field representative shall certify in writing to the Contractor that for each loop or system checked out, all discrepancies have been corrected by the installation personnel.

3.1.12 Removal of Abandoned Equipment: All existing instrument and control equipment that is no longer required after the new system has been put into service shall be removed and delivered to the Owner by the Contractor.

3.1.13 Control Circuit Wiring

- Wiring Installation: All wires shall be run in plastic wireways except field wiring, wiring run between mating blocks in adjacent sections, wiring run from components on a swing-

out panel to components on a part of the fixed structure, and wiring run to front panel-mounted components. Wiring run from components on a swing-out of front panel to other components on a fixed panel shall be made up in tied bundles. These bundles shall be tied with nylon wire ties and shall be secured to panels at both sides of the "hinged loop" so that conductors are not strained at the terminals. Signal and low voltage wiring shall be run separately from power and 120 volts control wiring.

- Wiring run to control devices on the front panels shall be tied together at short intervals with nylon wire ties and secured to the inside face of the panel using adhesive mounts with screws.

- Wiring to rear terminals on panel-mount instruments shall be run in plastic wireways secured to horizontal brackets run above or below the instruments in about the same plane as the rear of the instruments.

- Conformance to the above wiring installation requirements shall be reflected by details shown on the shop drawings for the Owner's review.

- Wire marking: Each signal, control, alarm, and indicating conductor connected to a given electrical point shall be designated by a single unique number which shall be shown on all shop drawings. These numbers shall be marked on all conductors at every terminal using white numbered wire markers which shall be plastic-coated cloth covered with clear heat shrink tubing or permanently marked heat-shrink plastic and must be durable, smudge and fade resistant.

3.1.14 RTU I/O Configuration

- Additional Requirements: Any power supplies, signal isolators, converters, interposing relays, etc. that are necessary to make existing signals and equipment compatible with the I/O cards shall be furnished and installed as a part of this Contract.

- The input/output signals to be connected to the new RTUs shall be only the existing input/output, plus any new instruments furnished under this contract, unless otherwise noted.

3.2 Calibration, Testing, and Start-up

3.2.1 Calibration: All instruments and systems furnished by the Contractor shall be calibrated after installation, in conformance with the component manufacturer's instructions. This shall provide that those components having adjustable features are set carefully for the specific conditions and applications of this installation and that the components and/or systems are within the specified limits of accuracy. Defective elements which cannot achieve proper calibration or accuracy, either individually or within a system, shall be replaced. This calibration work shall be accomplished by the technical field representatives of the System Supplier whom the Contractor shall require to certify in writing that for each loop of system, all calibrations have been made and that all instruments are ready to operate.

3.2.2 Proof of Conformance: The burden of proof of conformance to specified accuracy and performance is on the Contractor using its designated System Supplier. The Contractor shall supply necessary test equipment and technical personnel if called upon to prove accuracy

and/or performance, at no separate additional cost to the Owner, wherever reasonable doubt or evidence of malfunction or poor performance may appear.

3.2.3 Testing: All systems shall be exercised through functional and operational tests in the presence of the Owner in order to demonstrate achievement of the specified performance. Operational tests depend upon completion of work specified elsewhere in these Contract Documents. The scheduling of tests shall be coordinated by the Contractor among all parties involved so that the tests may proceed without delays or disruption by uncompleted work.

3.2.4 Start-up: When all equipment and systems have been assessed by the Contractor to have been successfully carried through complete operational tests with not less than a minimum of simulation and the Engineer concurs in this assessment, system start-up by the City's operating personnel may follow.

SECTION 18200
PROGRAMMABLE LOGIC CONTROLLER

1.0 PROGRAMMABLE LOGIC CONTROLLERS.

1.1 DESCRIPTION. This section specifies the requirements for a programmable logic controller (PLC) provided to monitor and control process conditions for City pump stations, lift stations, and other pump, motor or blower systems or subsystems.

NOTE

This section pertains to the configuration of the Lift Station Master PLC but includes packaged systems such as the PLC provided by the Pump Manufacturer and the Sewage Grinder Manufacturer. Those PLCs shall be as specified herein and compatible with the Master PLC. The PLC shall be supplied by the Instrumentation and Control Subcontractor (ICS) or the manufacturer of the packaged equipment system. The requirements of the individual equipment system are equally applicable to the work specified herein. Where conflict exists, the individual equipment system sections shall take precedence.

1.1.1 The equipment system PLC shall interface with the Plant and/or City Supervisory Control and Data Acquisition (SCADA) system, and shall include all components required for a complete, fully functional and operable process monitoring and control system.

1.1.2 The PLC shall include all required enclosures, chassis, power supplies, central processing units, input/output (I/O) systems, communication systems, interfaces, instruments, devices, wiring, and terminations, as specified herein and as shown on the Drawings.

1.1.3 PLC components specified herein shall be provided, as well as any ancillary or incidental equipment or devices, whether identified or not, that are required to support the monitoring and control of the equipment system and permit full use of the process equipment's capabilities.

1.2 RELATED SECTIONS. The Contract Documents are a intended to be single integrated document, and as such all Specification Sections apply. It is the responsibility of the Contractor and its subcontractors to review all sections and ensure a complete and coordinated project. Related Specification Sections include, but are not limited to, all sections of Division 16 and Section 18100.

1.3 REFERENCE STANDARDS AND CODES. All materials and equipment specified herein, including installation, shall conform to the applicable requirements of the following standards and codes (latest edition) to the extent that the provisions thereof are not in conflict with other provisions of these Specifications.

- International Society of Automation (ISA)
  - ISA S5.1 Instrumentation Symbols and Identification
  - ISA S5.3 Graphic Symbols for Distributed Control/Shared Display Instrumentation, Logic, and Computer Systems
  - ISA S5.4 Instrument Loop Diagrams

- National Electrical Manufacturers Association (NEMA)
  - NEMA 250 Enclosures for Electrical Equipment (1000 Volts Maximum)
  - NEMA ICS 6 Industrial Control and Systems: Enclosures

- National Fire Protection Association (NFPA)
  - NFPA 70 National Electrical Code (NEC)
  - NFPA 79 Electrical Standard for Industrial Machinery

- Underwriters Laboratories (UL)

  - UL 508A Standard for Industrial Control Panels
  - UL 698A Standard for Industrial Control Panels Relating to Hazardous (Classified) Locations

1.4 DEFINITIONS. The following definitions are used throughout this Section:

AI: Analog Input
AO: Analog Output
CPU: Central Processing Unit
DI: Digital Input
DO: Digital Output
EEPROM: Electrically erasable programmable read-only memory
HMI: Human-Machine Interface
I/O: Input and/or Output
LAN: Local Area Network

Peer to Peer: Communication between two or more devices, typically PLCs, in which each device can control the data exchange.
PID: Control action, proportional plus integral plus derivative.
PLC: Programmable Logic Controller
RAM: Random Access Memory
Remote I/O: Any and all I/O that is located remotely from the processor.
SCADA: Supervisory Control and Data Acquisition
TCP/IP: Transmission Control Protocol and Internet Protocol
UPS: Uninterruptible Power Supply

1.5 SUBMITTALS. All submittals shall be in accordance with the General Conditions and these specifications.

1.6 DESIGN REQUIREMENTS. The complete PLC shall be guaranteed to operate satisfactorily within the specified NEMA rated enclosure in ambient temperatures ranging from +32°F to +120ºF.

1.6.1 General Functions. As a minimum, the PLC system shall be designed to perform the following functions:

- Provide fully automated control of equipment system operation, including monitoring process conditions, providing control feedback, optimizing process performance, and interfacing with other Plant PLCs and/or the City SCADA system, as shown on the Drawings and as specified in individual equipment system sections and herein.

- Where specified, provide manual override of the automated controls via the HMI. Unless specified otherwise, critical system monitoring, alarm, and safety shutdown functions shall remain in effect.

- Unless specified otherwise, hold all system alarms locally until manually reset from the PLC HMI or from the SCADA system.

- Communicate with the SCADA system, which shall provide supervisory control of the equipment system operation via an Ethernet communication link.

- Provide control capabilities to restart the equipment system, including associated equipment, as required after a Plant shutdown or power failure in coordination with and as commanded by the SCADA system.

1.6.2 General Performance Capabilities and Features. As a minimum, the PLC system shall be provided with the following performance capabilities and features:

- The PLC shall be capable of handling analog inputs/outputs (4-20ma); and discrete inputs/outputs (contact closures, pulses; momentary or latch operation) in addition to power monitoring.

- Input/output modules shall be furnished to accommodate all process monitoring and control specified in the equipment system specifications and shown on the Drawings plus any additional modules not shown, but essential to controlling and

monitoring the system, providing a complete and final product.

- All control programs shall reside in the PLC. All monitoring and control functions specified in the equipment system specifications and control loops/logic diagrams shown on the Drawings, and any additional controls necessary for operation of the system, shall be supplied and implemented by the equipment system manufacturer.

- The PLC shall incorporate pre-programmed self-diagnostic software routines for maintenance.

- The PLC shall incorporate a watchdog function to monitor: internal CPU failure, CPU memory failure, loss of communication between CPU and I/O modules, and CPU failure to execute logic program.

- Unless specified otherwise, activation of alarms and stopping of equipment shall result from de-energization of control circuits, rather than energization of control circuits.

- Unless specified otherwise, PLC failure mode shall be designed such that the loss of PLC supply power or output control signals to the equipment shall result in the equipment shutting down or operating in a predetermined safe mode.

- PLC logic system failure shall not preclude proper operator intervention.

- Unless specified otherwise, safety shutdown of equipment or equipment system shall require manual operator intervention via PLC HMI prior to reestablishing operation of the equipment or system.

- Internal PLC system status and faults shall be monitored and displayed on the HMI. As a minimum, monitored items shall include:

    - Power-up diagnostic (self-test) - passed/failed.
    - Memory - OK/loss of memory
    - CPU - OK/fault
    - Program run Status - OK/fault
    - Scan time - OK/overrun.
    - Battery status – OK/low

As a minimum, each monitored item shall be displayed on the HMI on a single PLC system status screen.

1.6.3 PLC and HMI programming and configuration shall incorporate the following general strategies and functions:

- All calculations, analog value trip points, timers, etc. shall be accomplished in the PLC and not in the HMI.

- All analog inputs to the PLC shall be configured in the HMI software for historical trending.

- All set points for minimum and maximum values of analog outputs shall be operator

adjustable via the HMI software.

- All set points for minimum and maximum values of analog inputs for process monitoring/control shall be operator adjustable via the HMI software.

- All open/close automatic valves and remote start/stop motors controlled by the PLC system shall have an adjustable maximum time value allowed to either open/close or start/stop. Failure to achieve the control function within this maximum time value shall result in a time out alarm for each piece of equipment. An alarm shall be generated from the PLC to the HMI for indication of the control function time out failure (e.g. Pump XXX Fail to Start, Valve XXX Fail to Open).

- The status of all alarms shall be latched until manually acknowledged via the HMI.

- HMI entries by the operator, such as set points and operation modes, shall be displayed on the process screens for information.

1.6.4 Security. Prevent unauthorized access to PLC and HMI programs and configurations with password-based security in the PLC and HMI software.

1.6.5 Noise Suppression. The PLC system shall be designed with high noise immunity to prevent occurrence of false logic signals resulting from switching transients, relay and circuit breaker noise, or conducted and radiated radio frequency interference. Incorporate noise suppression and inductive load suppression design into PLC input, output, and logic modules.

1.6.6 Compatibility. At a minimum, the PLC system shall be capable of using Ethernet/IP, Modbus, and OPC as communication protocols to communicate with other PLCs on the network and Plant SCADA or District SCADA, as applicable.

1.6.7 Design and Fabrication. All PLC components such as PLC power supply, I/O modules, CPU, communication modules, backplane, wiring harnesses, etc. shall be provided with conformal coatings for protection against moisture and chemical contaminants. All PLC component connections shall be screw-in type. Plug-in type connections will not be acceptable. All terminal blocks shall be screw-in type and shall provide a location for identifying associated terminal numbers. Independent line fuses or circuit breakers shall be provided, per the manufacturer's recommendation, for each power supply, input module, output module, and other modules with separately derived power requirements. All communication signals and 4-20 mA signals shall be properly conditioned for the PLC and protected from all sources of radiated energy or harmonics.

1.6.8 Appurtenances. The PLC processor, I/O modules, power supplies, and communication modules shall be provided as a complete system, as specified in the equipment system specification section and herein, and as shown on the Drawings. The PLC shall include all necessary components and hardware for a complete and fully functional system.

- All special chassis or panel mounted power supplies, special interconnecting and programming cables, special grounding hardware, or isolation devices shall be furnished as required for proper operation of the equipment.

- Signal converters, signal boosters, amplifiers, special power supplies, intrinsically safe relays and current repeaters, surge suppression devices, and isolation devices shall be furnished and installed as required for proper operation of the equipment.

1.6.9 Fabrication, Installation, and Testing. Equipment and components shall be Underwriters Laboratory (UL) listed for the purpose or UL recognized. The assembled PLC panel and individual components shall be UL listed and labeled. The assembled panel shall have a factory applied UL 508A label. Where applicable, intrinsic safety barriers within the PLC panel shall be provided per UL 698A with factory applied labels as required by UL. The PLC system shall be factory tested prior to delivery.

1.7 INSTALLED-SPARE REQUIREMENTS. Each PLC shall be provided with the following spare capacities.

1.7.1 I/O points – 20 percent spare I/O capacity for each type of I/O signal required. All spare I/O shall be wired to the field terminal blocks.

1.7.2 PLC chassis and backplane – the greater of: 20 percent spare capacity, or 3 spare backplane slots. All spare backplane slots shall be equipped with slot filler modules.

1.7.3 PLC memory – 50 percent spare program volatile memory capacity after all required programming is in place and operating. Executive or "housekeeping" programs shall not be counted in memory size rating.

1.7.4 Field terminal blocks – 10 percent spare terminal blocks for each type of I/O signal required. These spare terminal blocks shall be in addition to the wired terminal blocks required for spare I/O capacity.

1.8 SPARE PARTS

1.8.1 Each PLC shall be provided with the following spare parts. Spare parts shall be packaged for long term storage and identified with labels describing contents.

- I/O Modules: provide a spare of each type of module installed.
- CPU: provide a spare for each type of CPU installed.
- PLC Power Supplies: provide a spare for each type of power supply installed.
- Memory Cards: provide a spare for each type of memory card installed.
- Communication Module: provide a spare for each type of communication module installed.

1.8.2 Provide manufacturer's recommended special tools for the PLC and associated components. Special tools should include module installation/removal tools, terminal block installation/removal tools, reset tools, and drivers for special fasteners and screws.

1.9 MANUFACTURER SERVICES AND COORDINATION. The ICS or packaged equipment system manufacturer shall design, engineer, fabricate, program, factory test, and deliver to the project site a complete and fully functional PLC to provide process monitoring and control of the specified equipment system and to interface with the Plant

and/or District SCADA system. The manufacturer shall coordinate with the Contractor, Electrical Subcontractor, Instrumentation and Control Subcontractor, and City to ensure proper communication between PLC, Plant equipment, instrumentation and control devices, and SCADA system(s). The ICS or packaged equipment manufacturer shall provide qualified and experienced engineering representatives to participate in project software development and coordination workshops with the District. As a minimum, the manufacturer's representatives shall attend two (2) separate workshop sessions (one half day per session). The workshop sessions shall address the following:

- PLC I/O list. Conventions for tag names and addressing.
- PLC program monitoring and control strategy.
- PLC local/remote and auto/manual control modes.
- PLC communication and control approach (PLC to PLC, and SCADA to PLC).
- Alarm acknowledgment and reset strategy.
- Software security.
- Procedure for automatic restart following a power failure.
- HMI screens (standard objects, data display, and color conventions).

[After the equipment system has been installed, the manufacturer shall perform pre- startup, startup, commissioning, and field testing of the system. Upon completion of system startup and testing, the manufacturer shall provide the City with a certificate of proper installation, and provide onsite training to District personnel.]

1.10 QUALITY ASSURANCE. The City believes that the manufacturers listed herein are capable of producing equipment and/or products that will satisfy the requirements of these Specifications. The listing of specific manufacturers herein does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed herein are not relieved from meeting these Specifications in their entirety; and, if necessary, they shall provide non-standard, custom equipment and/or products. Contractor shall be responsible for confirming that the proposed equipment and/or products will meet these Specifications. Products of one manufacturer and of the same series or family of models shall be used to achieve standardization for appearance, operation, maintenance, spare parts, and manufacturer support services.

2.0 MATERIALS AND PRODUCTS

2.1 PLC CAPABILITIES AND PERFORMANCE. The PLC shall

- Collect data, perform process control functions, communicate with other PLCs, and distribute process information along the local area network.

- Be capable of providing proportional, integral, and derivative control in real time, with preemptive priority multitasking.

- Be able to have its program downloaded from a remote workstation over the local area network, and be locally programmed from a portable laptop computer.

- Be field expandable to allow for the expansion of the system by the simple addition of hardware and configuration of same.

- Have a controller, or I/O module capable of being inserted under power, without upsetting the process being controlled by other controllers.

- Have the capability to preselect the failure status of each output point in the event of CPU failure.

2.2 PLC SOFTWARE REQUIREMENTS. As a minimum, the PLC programming software shall allow the use of all textural and graphic languages specified in IEC 61131-3, including Relay Ladder Diagram (LD), Function Block Diagram (FBD), Structured Text (ST), and Sequential Function Chart (SFC).

2.2.1 The processor shall be able to program in all four languages in one processor. Standard Boolean logic for coils, timers/counters, etc., shall only be limited by the amount of memory in the processor.

2.2.2 All memory locations shall be tag based with the ability to add and delete online without taking the processor offline. In addition the tags shall have the ability to be named to reflect usage based on user conventions. The tags shall also have the ability to be aliased to other tag names if required.

2.2.3 The PLC shall be programmed using a single programming software package. The programming software package shall have integrated tools for PLC programming, network configuration, and communication capabilities. PLC's that use separate programming, communication, and network configuration software will not be accepted. The programming software shall run on general purpose personal computers with Windows 10 (or latest) operating systems.

2.2.4 The PLC system shall have capability to password protect access to the PLC. The system shall ensure security by authenticating users against a set of defined user accounts and access privileges.

2.3 PLC HARDWARE

2.3.1 Main PLC. The PLC shall be an integrated, modular, chassis type system designed for mounting the CPU (processor) module, I/O modules, communication modules, and power supply unit. The PLC shall be Allen Bradley 1756 ControlLogix or 1769 CompactLogix System, or approved equal. Approval shall primarily be focused on technology currency and compatibility with existing systems, at the discretion of the Engineer.

2.3.2 Processor. The PLC system shall execute logic in a single processor module. The processor shall be capable of executing all monitoring and control functions required by the Specifications and Drawings. The processor shall have the ability to run multiple tasks with the ability to run each task at a particular scan rate that may be updated while running with the ability to prioritize each task. The processor shall have a minimum of 8 MB of base program and data memory. Specified memory capacity shall be available entirely for storing the operational control program. Specified spare capacity and executive or "housekeeping" programs shall not be counted in memory size rating. A non-volatile memory card (EEPROM or Flash Memory) shall store the entire user program and configuration, and shall be capable of reloading the program into RAM if a fault in the program is detected or if the program is lost due to loss of battery power or other means. The non-volatile memory card shall have a minimum of 8 MB of memory. As a minimum, the processor shall be provided with one built-in USB port.

The required 10BASE-T/100BASE-TX RJ45 Ethernet/IP ports shall be provided as built-in ports and/or via separate communication modules. The processor will be capable of being programmed with a general purpose laptop computer.

2.3.3 I/O Modules. PLC I/O modules shall be provided as required to accept signals as indicated on the drawings, in the Specifications and as specified herein. I/O modules shall be provided to accept all active signals and all specified spares. PLC I/O modules, including installation in the PLC enclosure shall conform to the following:

- All I/O modules shall be enclosed in a plastic housing. I/O modules shall be plugged into a modular type I/O rack with common backplane. All cables required to connect to all other PLC system components shall be provided.

- I/O modules shall be capable of being removed and inserted into the I/O rack under power without affecting any other I/O modules in the rack.

- I/O of a particular type (digital inputs, digital outputs, analog inputs, and analog outputs) shall be grouped together.

- All I/O wiring shall be to removable terminal blocks that permit removal and replacement of a module without disturbing the wiring or any other I/O module. Removable terminal blocks shall be suitable for accepting #14 AWG I/O wiring.

- Identify on I/O modules and associated terminal blocks, the specific I/O points as they have been addressed in the PLC system.

- All field wiring shall be terminated on terminal blocks within the PLC enclosure. The field terminal blocks shall be sized to accommodate all active I/O points and required spares. Field terminals shall be provided for the individual termination of each analog signal shield. The PLC shall be factory prewired between the field terminal blocks and I/O module removable terminal blocks.

2.3.4 Communications. Communications shall be capable of using Modbus, and open industry standard Ethernet/IP and OPC protocols. The PLC shall be capable of peer-to-peer communications that provide for the direct transfer of process data between controllers without the use of gateways or servers. PLC chassis shall be capable of containing one or more communication modules to provide communication interfaces to other devices, including, but not limited to: remote work stations, HMIs, and PLCs by other manufacturers. As a minimum, the PLC shall support Ethernet (10/100MB) and serial protocols including Modbus without the need for third-party modules. The PLC shall be provided with an Ethernet module equipped with multiple ports (at least 2 ports). Each port shall be capable of communicating both TCP/IP and Ethernet/IP simultaneously. Modules requiring the ports to be configured for one protocol will not be acceptable. The communication module shall also support daisy-chain wiring. Surge protection shall be provided on all connections to communication ports.

2.3.5 Chassis. The PLC shall be provided with a chassis to mount the processor module, I/O modules, communication modules, and other applicable modules. The chassis shall be modular, capable of accepting any module into any slot. The chassis backplane shall provide a high speed communication path between modules and distribute power to each of the modules within the chassis. Modules shall be secured to the chassis via a screw connection. The

chassis shall be available in various slot configurations, up to a total of 17 slots.

2.3.6 Power Supply. Each PLC shall be provided with a regulated power unit designed to operate the PLC system. The power supply unit shall mount directly to the chassis and connect to the chassis backplane and provide power to the PLC system, including the controller processor, I/O modules, communication modules, and other applicable modules and all associated two-wire field instruments.

- Capable of supplying PLC system power when all the specified spare I/O capacity is utilized.

- Sized to carry no more than 75 percent of total unit capacity under normal loads, including all spare capacity.

- Provide constant voltage level DC distribution to all devices. Power distribution shall be immune to transients and surges resultant from input power noise.

- A single power supply unit shall be provided for each chassis. The input power to the power supply shall be 120VAC, +/- 10 percent, 60 Hz. Provide a separate line fuse shall be provided for each power supply unit.

2.3.7 Uninterruptable Power Supply (UPS): Provide UPS Model Smart-UPS manufactured by APC or approved equal. Unless specified otherwise, each PLC shall be provided with a UPS. Alternatively, each PLC may be powered from a single UPS, at the Contractor's option, provided it is located in an interior control room. The UPS shall

- Ensure that transient power surges and dips do not affect the operation of the PLC system.

- Utilize low maintenance, rechargeable, sealed batteries, maintained at a float point charge during normal power conditions.

- The UPS switch to and from battery in less than 4 milliseconds.

- Provide silencing audible and visible alarm indicating low battery. Provide a serial port interface to communicate with the panel PLC. This interface shall provide information to alert Plant of a low battery warning, power alarm, or UPS failure.

- Be sized to sustain full power to the following loads for a minimum of 15 minutes after loss of primary power for PLC power supply unit, including all chassis mounted PLC modules and associated two-wire field instruments, PLC Human-Machine Interface, and all power supplies furnished with the PLC and associated loads. Provide an AC circuit breaker for the line power to the UPS.

2.4 HUMAN-MACHINE INTERFACE (HMI). The Contractor shall provide a door- mounted Human-Machine Interface (HMI) for the Main Station Master PLC and the Pump PLC. The PLC for the Grinder Station need not have a separate HMI. The pertinent interface information required of either shall be provided or duplicated at the Main PLC HMI.

2.4.1 Unless specified or approved otherwise, each HMI shall meet or exceed the following

requirements:

- Display size: 12 inches or larger, Touchscreen, back-lit, color TFT LCD, 18-bit color
- OS: Microsoft Windows, Open Architecture
- Processor Frequency: 1 GHz
- RAM: 512 MB
- Internal Storage: 512 MB
- Operating Temperature Range: 32-140 Deg F
- Enclosure: NEMA 4X, 12 and 13
- Software: FactoryTalk or equal, PDF Viewer, ActiveX Controls, FTP Server

2.4.2 Manufacturer/Model: Allen-Bradley PanelView Plus 7 or equal.

2.5 PLC ENCLOSURE AND APPURTENANCES.

NOTE

As shown on the drawings, the Contractor is to configure and provide a single, integrated, motor control center and control equipment cabinet assembly in the control room or space

NOTE

The purpose of the single cabinet assembly is to ensure that the power and control systems are integrated, irrespective the individual subcontractors, suppliers, and installers, that the package presents a uniform, symmetrical and uncluttered appearance which is readily understood by maintenance personnel, and which can hereafter be configured as a City Standard. Accordingly, the requirements of paragraphs 2.5.1 through 2.5.5 may be construed as guidance and standard rather than restrictive specification, subject to the normal Submittal Process.

2.5.1 The PLC enclosure shall be of sufficient size to house all PLC and HMI hardware, power supplies, instruments, relays, devices, terminal blocks, wireways, and appurtenances as specified herein and required for each equipment system application.

2.5.2 Unless specified otherwise, PLCs located outdoors or indoors in corrosive or wet locations shall be provided with NEMA 4X enclosures constructed of Type 316 stainless steel. Unless specified otherwise, PLCs located indoors in non- corrosive and dry locations shall be provided with NEMA 12 enclosures. Enclosures shall be free-standing or wall mountable. (See Note below.)

2.5.3 NEMA 4X enclosures shall be provided with solid exterior door(s) and interior hinged swing-out door(s) for mounting HMIs, instrument displays, lights, switches, pushbuttons, etc. All PLC enclosures shall be supplied with removable equipment mounting back panels and pad-lockable doors equipped with 3-point latching systems, inner drawing holders, and

neoprene seals.

2.5.4 The interior of NEMA 12 enclosures shall be painted white and the exterior shall be painted gray. All enclosure interior mounting brackets, panels, and plates shall be painted white. Enclosures equipped with single doors shall be hinged to swing from right to left and shall be easily removable.

2.5.5 Each PLC panel shall be provided with LED lighting fixtures of sufficient size and quantity to provide 50 foot-candles of illumination within the panel. The lighting fixtures shall be horizontal LED tube type fixtures and shall be mounted to the top of the enclosure. The light fixtures shall be wired to a UL-approved switch mounted inside the panel. Each PLC panel shall be provided with a duplex, 120VAC, 15A, 3-wire grounded GFCI type convenience receptacle. The light fixture(s) and convenience receptacle shall be powered from a separate voltage source than the PLC equipment.

2.6 INTERPOSING RELAY SUBASSEMBLIES. Where applicable,

2.6.1 24 VDC interposing relays shall be utilized on all digital outputs which are required to interact with the motor control center, VFDs, valves and external hardwired logic circuitry. Octal socket plug-in relays containing two form “C” 10 amp contacts shall be supplied. Each relay shall contain an internal LED indicating when the relay has been energized. Relay coils shall be wired to the load side (output) of the supplied PLC field terminal block and labeled to reflect the I/O address which drives it. A 1-amp, 100V (1N4001) surge suppression diode shall be wired across the relay coil socket pins. Interposing relay contacts shall be wired with yellow wire to the line side (input) of a separate isolated field terminal block dedicated to interposing signals. All wires between relay contacts and the interposing signal terminal block shall be labeled to reflect the relay/pin number.

2.6.2 Interposing relays shall be provided in subassemblies consisting of 4 relay sockets mounted onto an interposing relay mounting plate, and prewired with a color-coded wire harness for connection to terminal blocks, as described above. All hardware for mounting the subassembly into the PLC enclosure shall be provided, and a nameplate tag for relay identification shall be provided for each relay socket. Mounting of interposing relay subassemblies shall be simplified while maintaining the integrity of the enclosure’s NEMA rating, maintaining serviceability without the removal of other equipment, and preventing interference with the removal or serviceability of other equipment.

2.7 WIRING.

2.7.1 All terminal blocks shall slide onto a single symmetrical steel DIN mounting rail. The terminal system shall be a finger-safe, multi-circuit (3 circuit minimum), compact, high-density design utilizing a stainless steel screw with nickel plated copper or brass pressure plate wire terminating construction. The terminal block system shall allow for installation ease where the addition of terminals simply requires sliding clear a space on the rail and snapping into place the new terminal modules. All terminals shall be rated for 600 volts with a maximum current of 20 amps, UL rated, and shall accommodate wires ranging between #24 to #12 AWG. All terminals shall have a place for marking the wire number associated with them. All terminal blocks shall be manufactured by Phoenix Contact, or equal.

2.7.2 All analog inputs and outputs shall be terminated onto fused signal isolation terminal modules in order to protect the PLC I/O modules from accidental field wiring errors, ground loops, disparate supply voltages and short circuits. Power feeds, external power

supply outputs, and other power distribution wiring to external equipment shall be terminated on a fused terminal. All fused terminal blocks shall be equipped with fuses, including all spare terminal blocks.

3.0 CONSTRUCTION.

3.1 FABRICATION. Refer first to "NOTE" at paragraph 2.5.

3.1.1 The PLC chassis shall be mounted at the top of the enclosure back panel. Provide spacing around the PLC as required by the PLC manufacturer to ensure: adequate cooling, clearance space for cabling, and access for servicing. PLC communication ports, and memory card slots shall be accessible at all times. PLC lights shall be visible at all times when the enclosure door is opened.

3.1.2 The field wiring terminal block subassemblies shall be located at the bottom of the enclosure back panel for easy access and routing of external wiring.The UPS and UPS power receptacle shall be located at the bottom of the enclosure.

3.1.3 The interposing relay subassemblies shall be mounted on the enclosure back panel or enclosure sides, whichever is most convenient for serviceability and panel size minimization while maintaining the NEMA rating. All relay sockets shall be prewired to terminals as described above. I/O modules shall be prewired with cable subassemblies to terminal blocks with color-coded (individually shielded pairs for analog signals) and neatly routed in an orthogonal fashion along the bottom of the PLC modules, panel sides and top of the terminal block subassemblies. Slotted wire ducts with removable covers shall be used for wire and cable routing. The number of cable subassemblies and type shall correspond to the number and type of I/O.

3.1.4 Each PLC component shall include a clearly visible faceplate with appropriate data such as the manufacturer’s model number. In addition, nameplates engraved with the name/function of each PLC component shall be provided. Each nameplate shall be mounted adjacent to the respective component in a clearly visible location. All cables and connectors required for proper operation of all PLC components and accessories shall be furnished by the manufacturer, and shall be factory installed and tested.

3.2 INSTALLATION. Install the PLC panel in the location shown on the Drawings. Installation shall be in accordance with the manufacturer's written installation instructions and as specified herein. The PLC panel shall be rigidly support, plumb and level, and in such a manner as to provide accessibility and freedom from interference with other equipment, piping, or electrical work. Provide a 3-inch high concrete or steel frame housekeeping pad upon which to place the MCC and control cabinets. Anchor panels in accordance with the manufacturer's recommendations. All field wiring and cabling shall be connected to the PLC field terminal blocks in accordance with the approved shop drawings. All grounding shall be connected as shown on the plans and approved shop drawings.

3.3 FIELD QUALITY CONTROL. The Contractor, ICS or packaged equipment system manufacturer shall provide a qualified service representative to:

- Inspect the PLC, wiring, components, connections, and equipment installation. Perform all necessary pre-testing, operational checks, and adjustments of the supplied programmable controller, components, and equipment to ensure that the PLC is ready for operation.

- Assist in field testing of PLC and equipment system, including all programming for monitoring and control of the equipment, provide a written report documenting all field testing and results, and provide written certification that the PLC system has been properly installed, started up, fully tested, and is ready for operation by the City.

3.4 FIELD TESTING. After the PLC system installation has been certified and all analog points have been tested and calibrated, the entire system shall be tested to verify that on discrete and analog inputs and outputs are functioning correctly.

3.4.1 I/O points shall be tested from end-to-end without simulation, to the maximum degree feasible without causing damage to the equipment. Simulated testing will only be allowed when no practical alternative exists. I/O checklists shall be provided by the ICS or packaged equipment manufacturer to record the test results, with a copy provided to the Engineer upon completion of testing.

3.4.2 Following testing of the individual I/O points, system operational testing shall be performed. System operational testing shall demonstrate proper operation of the various processes monitored and controlled by the PLC, including automatic control modes and control system interlocks. All functional requirements shall be verified.

3.4.3 Tests that fail to demonstrate the required operation shall be repeated in their entirety after corrective action has been completed. During system testing, the ICS or packaged equipment manufacturer shall have a representative onsite continuously who is capable of troubleshooting and modifying the control system programming. Upon satisfactory completion of all field testing, the ICS or packaged equipment manufacturer shall submit a system testing report to the Engineer documenting all performed testing and testing results.

3.5 TRAINING. Upon satisfactory completion of all field testing and commission procedures, the ICS or packaged equipment manufacturer shall provide the services of a factory trained representative to provide onsite training of City personnel in the operating and maintenance of the furnished equipment. Training shall include classroom, hands-on instruction, practice exercises and demonstrations, and shall address

- PLC system hardware overview
- PLC and HMI software overview
- Service, Maintenance and Troubleshooting.
- Changing set points, manual overrides, passwords, etc.

1.0 MULTI-CHANNEL DATA ACQUISITION SUBSYSTEMS

1.1 DESCRIPTION. This section specifies the requirements for a complementary or redundant data acquisition subsystem designed and configured to independently monitor pump stations, lift station, line or tower status with signals from the Master Station PLC and certain other remote sensors and report such data automatically to a host computer by means of digital packet switched cellular system.

NOTE

This section pertains to the provision, configuration and commissioning of a data acquisition subsystem consisting of a cellular communications system, data logger, rain gauge sensor, and source level or pressure data. The intent of this subsystem is to select data provided to and generated by the Main PLC and transmit same to a host computer for web-based data reporting and monitoring.

1.1.1 The Main Station PLC controls the station. This subsystem gathers data and signals, records and then transmits to a host computer off-site. The Main PLC shall interface with the Plant and/or City Supervisory Control and Data Acquisition (SCADA) system now in existence or to be developed in the future. The subsystem described here monitors but does not control the station operation and function, unless otherwise required following.

1.1.2 This monitoring subsystem shall include all required enclosures, chassis, power

supplies, input/output (I/O) systems, communication systems, interfaces, instruments, devices, wiring, and terminations, as specified herein and as shown on the Drawings. Contractor shall provide any ancillary or incidental equipment, devices, or services, whether identified or not, that are required to support the monitoring subsystem and permit full use of the subsystem capabilities.

1.2 RELATED SECTIONS. The Contract Documents are a intended to be single integrated document, and as such all Specification Sections apply. It is the responsibility of the Contractor and its subcontractors to review all sections and ensure a complete and coordinated project. Related Specification Sections include these specifications and the special specifications for each project or installation.

2.0 MATERIALS AND PRODUCTS. Components include a Multi-Channel Data Acquisition Subsystem consists of 2 principal components:

- Wireless Remote Telemetry Unit (RTU), Telog Brand RS-3314; and

- Data Logger and Rain Gauge, Telog Brand RG-32 and GR-6.

2.1 The Recording Telemetry Unit (RTU) includes data recorder, cellular data modem, and AC power supply with battery back-up.

2.1.1 The RTU shall be packaged in a NEMA 3 enclosure intended for use and installation in the control cabinetry of the MCC in the control building. The RTU is intended to operate in a network to a computer operating a host application program in a Microsoft Windows® Operating System environment. The RTU shall support 14 channels, 8 analog and 6 discrete inputs. The recorder shall sample each analog input channel at a user-selected rate from 1 second to 8 hours.

- The discrete channels shall be user configurable to record events or interval pulse totals. In the event mode, the recorder will capture the time stamp (*mm:dd:yy hh:mm:ss)* for each recorded event. In the pulse mode, the recorder will count up to 20,000 pulses per second. These pulses shall be collected over a user-defined period, which shall be selectable from 1 second to 8 hours. At the end of each interval period, the recorder shall save the total of the pulses.

- The recorder shall offer two types of recording modes. First, the recorder shall be capable of sampling and storing data continuously. Second, (for the analog channels only) the recorder shall be capable of threshold exceedance recording. In this mode, it shall only store data when user-preset high/low thresholds are exceeded.

2.1.2 Data Retrieval. Data may be retrieved from the recorder via a local serial interface port. Host software support shall be available to permit transferring data from the recorder using a Laptop and Telog for Windows Software.

2.1.3 Data Communications. In addition to local communications, the recorder shall be capable of automatic communications with the Host computer via digital packet switched cellular *(1xRTT*).

- Communications may be configured so that the recorder may call the Host computer on

a schedule and/or under alarm exceedance conditions. With the Verizon Wireless cellular modem option, communications shall operate over the CDMA 800 MHz networks digital cellular networks.

- The data acquisition unit shall be supplied with a 1/4 wavelength, 3 dB gain antenna that screws onto watertight, bulkhead connector mounted with extension cable mounted on top of the control building.

2.1.4 Power**.** The AC power options shall include AC to 12-volt DC power supply plus a lead-acid rechargeable battery and a charging circuit for the battery. The AC/DC power supply shall operate on 115 VAC and rated at 25 watts providing sufficient output to power customer provided instruments and sensors.

2.1.5 Enclosure**.** The recorder, cellular modem, AC power supply and back-up battery shall be housed in the control room cabinetry. (The RTU measures approximately 13 x 11 x 6 inches.) Connectors and/or watertight fittings shall be pre-installed for AC power, sensor inputs, communications interface and antenna connection.

2.1.6 Model. The above-specified system consists of Telog models:

- RS 3314 Recorder - 8 analog and 6 discrete input channels
- L1V- LTE Cellular Modem – Verizon
- E2- NEMA 3 enclosure 16x13x7, for MCC mounting
- AC12B4- Power Supply w/battery back- up,
- PS-12T2S, 120/230 VAC, 50/60 HZ C-31 Communication Interface Cable
- A-EMA-LTE Antenna Option A-PMA Pole mounted antenna with 15’ of cable

- C-USB-RS232 Data Transfer Dongle

The equipment and services shall be provided by Telog Instruments, Inc., represented by Macaulay Controls Company 972-769-1226.

2.1.7 Data Hosting and Cellular Service. Contractor Telog shall provide, set-up and include the cost for a two year 2-MB plan for data hosting and cellular service by Telog Instruments. Telog shall also set up and provide Verizon cellular account for City to be subsequently billed to City Engineer annually.

2.2 Enterprise Software and Data Management Service. Provide, set up, troubleshoot and commission

2.2.1 Telog Model S-3E/15 Enterprise Server and Enterprise Client with support expandability to 15 sites and 150 measurements.

2.2.2 Telog Model S-3E-WSA Web Module to enable posting data reports from Enterprise database to web site complete with web site administration utility.

2.2.3 Telog Model S-3E-CL Enterprise Client, additional Client seats

2.2.4 Provide, set up and troubleshoot

- Remote Installation and On-Site Training;

- Annual Software Maintenance Program for 1 year;
- 8 Hours initial training
- 4 Hours Annual Web Training or Refresher Training.

2.3 Enterprise Hardware and Software. Provide, install, set up, and commission 2 complete, stand-alone computer systems as follows for placement at Main Plant and Engineer Office.

2.3.1 Computer Hardware and Software (Minimum)
- Server Processor: 2GHz 64bit (x64) processor
- RAM: 2GB per CPU
- Hard drive space: 500GB
- Network Adapter: 1 GB

2.3.2 Telog Data Management Server System:
- Dell 2950 rack mount server
- Intel Dual Core Xeon 3GHz processor
- 8GB RAM
- 4 each 300Gb Ultra 320 SCSI Drives configured RAID 10
- 1 Gigabit Network Adaptors
- Redundant power supplies
- Windows Server 2008 Standard Edition

2.3.3 Computer Hardware Workstation (2 each)
- Processor: 2GHz 64bit (x64) processor
- RAM: 2 GB
- Hard drive space: 2GB
- Network Adapter: 200 Mbit minimum
- Operating System: Workstation MS XP Pro or Windows 7 Pro

2.3.4 Computer Software: Microsoft .NET Framework 4.0 with Telog Web module Microsoft IIS ver. 7 or above and server installation with Database SQL 2008 Express

2.3.5 Connectivity. Plant internet connection is Verizon broadband wireless. Engineer office is fiber optic cable service-based. Open inbound TCP port (4020 by default) for 1xRTT and GPRS applications

2.4 Wireless Rain Gauge Logger and Tipping Bucket Gauge. Provide Telog Rain Gauge Logger RG-32 and Tipping Bucket GR-6.

2.4.1 Wireless Rain Gauge Logger shall be packaged in a NEMA 4X enclosure intended for outdoor use or, alternatively, and preferably, mounted in the control room motor control cabinet as shown on the drawings. The single channel pulse/event recorder is to be used with Telog GR-6 Tipping Bucket Rain Sensor.

2.4.2 Features and Functions. The RG-32 single channel pulse/event recorder shall support a GR Series Tipping Bucket to continuously monitor the output of the tipping bucket rain gauge collecting rainfall data in a user defined time increment. Recorded data is automatically transferred over a cellular network (Verizon) to a host computer.

2.4.3 Power. Powered by a single user replaceable D cell lithium battery or connect to low voltage control power. Free standing anodized aluminum collector with bracket for pole mounting to east side of control building. Include 25' cable, 22 gauge 2 conductor, tamper-proof cable and software required for operation.

2.4.4 Communications. Connect output to and integrate with RS-3314 cellular packet data (Verizon) network to the computer operating the host application program. Otherwise, provide installation and set up with 2-year 2-MB plan for data hosting and cellular service by Telog Instruments.

2.4.5 Model. The above-specified system model number is Telog RG-32c/GR-6. Equipment and services are available from Telog Instruments, Inc., represented by Macaulay Controls Company 972-769-1226.

SECTION 9 PROCESS SYSTEMS
SUBSECTION 4 FACILITIES

To be published