CONTRACT DOCUMENTS
AND
SPECIFICATIONS
FOR
PROJECT NO. WPC 20-1
FY’20 WATER POLLUTION CONTROL
CAPITAL EQUIPMENT REPLACEMENTS

ATTENDANCE AT PRE-BID CONFERENCE IS MANDATORY

PREPARED BY:
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CLAYTON EDWARDS, P.E., DIRECTOR
WATER AND SEWER DEPARTMENT

Account Numbers: 7503382-544003, 7503392-544003, 7503395-544003

Water and Sewer Department
175 E. 2nd Street, Suite 1400
Tulsa, Oklahoma 74103
(918) 596-9845

TECHNICAL SPECIFICATIONS
PROJECT SPECIFICATIONS
FOR
TULSA METROPOLITAN UTILITY AUTHORITY

PROJECT NO. WPC 20-1
FY’20 WATER POLLUTION CONTROL CAPITAL EQUIPMENT REPLACEMENTS
TULSA, OKLAHOMA

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INTRODUCTION:

200.1 Project work shall include all equipment, labor, materials, hardware, cable, terminations, and incidentals necessary to remove existing equipment that is to be replaced, install the new equipment, and place the new equipment in fully operational, functional and warrantable service. All equipment to be supplied shall be brand new current year model and not used, remanufactured, or discontinued items.

200.2 The Authority’s contact people are:

<table>
<thead>
<tr>
<th>Water Pollution Control:</th>
<th>Matt Vaughan – Section Manager</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>175 E. 2nd Street, Suite 1400</td>
</tr>
<tr>
<td></td>
<td>Tulsa, OK 74103</td>
</tr>
<tr>
<td></td>
<td>918-596-9845</td>
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<tr>
<td></td>
<td><a href="mailto:mvaughan@cityoftulsa.org">mvaughan@cityoftulsa.org</a></td>
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</tbody>
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<table>
<thead>
<tr>
<th>Northside Wastewater Plant</th>
<th>Shawn Glen – Northside WWTP and Lower Bird Creek WWTP Superintendent</th>
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<tbody>
<tr>
<td>Lower Bird Creek WWTP</td>
<td>5628 N 105th East Avenue</td>
</tr>
<tr>
<td>Port South Lift Station</td>
<td>Tulsa, OK 74117</td>
</tr>
<tr>
<td></td>
<td>918-591-4570</td>
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<table>
<thead>
<tr>
<th>Southside Wastewater Plant</th>
<th>Josh Fisher – Southside WWTP Superintendent</th>
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<tr>
<td>Southeast Basin Lift Station</td>
<td>5300 S. Elwood Avenue</td>
</tr>
<tr>
<td></td>
<td>Tulsa, OK 74107</td>
</tr>
<tr>
<td></td>
<td>918-591-4450</td>
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</table>

201 QUALIFICATION REQUIREMENTS

201.1 Only contractors holding a valid pre-qualification certificate from the Tulsa Metropolitan Utility Authority in Classification A or D, General Utility Constructions, are eligible to bid on this project. No additional qualification information is required to be submitted.

201.2 Only contractors that attend the mandatory pre-bid meeting will be allowed to bid on this project.

202 SUMMARY OF BID ITEMS

The Basis of Award shall be determined by the total base bid plus additive alternates No. 1, 2, 3, 4, 5 and 6. Additive Alternate(s) No. 1-6 may or may not be awarded at the sole discretion of the City of Tulsa. Any proposal submitted with Additive Alternates No. 1-6 incomplete shall be considered non-responsive.
<table>
<thead>
<tr>
<th>BID ITEM</th>
<th>SPEC NO.</th>
<th>DESCRIPTION</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>203.998</td>
<td>Mobilization</td>
</tr>
<tr>
<td>2</td>
<td>203.100</td>
<td>All materials, labor, equipment, and supervision required for the Slide Gate and Level Sensor Improvements at the Interceptor LS at Northside WWTP per these specifications.</td>
</tr>
<tr>
<td>3</td>
<td>203.160</td>
<td>All materials, labor, equipment, and supervision required for the Headworks Screen Modifications at Northside WWTP and Cherry Creek LS at Southside WWTP per these specifications.</td>
</tr>
<tr>
<td>4</td>
<td>230.200</td>
<td>All materials, labor, equipment, and supervision required for the RAS Door Improvement and Demolition of the buildings gas monitoring and alarm system at Lower Bird Creek WWTP per these specifications.</td>
</tr>
<tr>
<td>5</td>
<td>203.300</td>
<td>All materials, labor, equipment, and supervision required for the Digester 1 &amp; 2 Building Drain and Roof System at Southside WWTP per these specifications.</td>
</tr>
<tr>
<td>6</td>
<td>203.400</td>
<td>All materials, labor, equipment, and supervision required for the RDT Polymer System at Southside WWTP per these specifications.</td>
</tr>
<tr>
<td>7</td>
<td>203.500</td>
<td>All materials, labor, equipment, and supervision required for the Sewage Flow Meter Vault, Isolation Valve and pump #4 discharge valve at Southeast Basin LS per these specifications.</td>
</tr>
<tr>
<td>8</td>
<td>203.600</td>
<td>All materials, labor, equipment, and supervision required for the Cherry Creek FEB #4 Levy Rehabilitation at Southside WWTP per these specifications.</td>
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<tr>
<td>9</td>
<td>203.620</td>
<td>All materials, labor, equipment, and supervision required for the Waterline Painting and Signage at Southside WWTP per these specifications.</td>
</tr>
<tr>
<td>10</td>
<td>203.720</td>
<td>All materials, labor, equipment, and supervision required for the Clarifier Walkway and Site lighting at Northside WWTP per these specifications.</td>
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<tr>
<td>11</td>
<td>203.730</td>
<td>All materials, labor, equipment, and supervision required for the Operations Building Panel Board Improvement at Northside WWTP per these specifications.</td>
</tr>
<tr>
<td>12</td>
<td>203.740</td>
<td>All materials, labor, equipment, and supervision required for the Gallery #2 Interior Lighting Improvements at Northside WWTP per these specifications.</td>
</tr>
<tr>
<td>13</td>
<td>203.750</td>
<td>All materials, labor, equipment, and supervision required for the DAF Facility Fans and Louvers at Northside WWTP per these specifications.</td>
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<tr>
<td>14</td>
<td>203.770</td>
<td>All materials, labor, equipment, and supervision required for the Port South ATS at Lower Bird Creek WWTP per these specifications.</td>
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<tr>
<td>15</td>
<td>203.820 &amp; 203.860</td>
<td>All materials, labor, equipment, and supervision required for the Secondary Effluent Pump Station Electrical Improvements at Southside WWTP per these specifications.</td>
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<tr>
<td>16</td>
<td>203.940</td>
<td>All materials, labor, equipment, and supervision required for the Phase 2 Exterior Lighting Improvements at Southside WWTP per these specifications.</td>
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<tr>
<td>Add Alternate No.</td>
<td>203.XXX</td>
<td>Description</td>
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</tr>
<tr>
<td>17</td>
<td>203.999</td>
<td>Mechanical, Electrical, Plumbing and Unforeseen Circumstances Allowance for various mechanical, electrical, plumbing and unforeseen work not shown on the construction drawings or specified in the contract documents.</td>
</tr>
<tr>
<td>18</td>
<td>203.120</td>
<td>All materials, labor, equipment, and supervision required for the Operations Building Floor Rehab at Northside WWTP per these specifications.</td>
</tr>
<tr>
<td>19</td>
<td>203.250</td>
<td>All materials, labor, equipment, and supervision required for the PEW Programming Improvements at Northside WWTP per these specifications.</td>
</tr>
<tr>
<td>20</td>
<td>203.240</td>
<td>All materials, labor, equipment, and supervision required for the Outfall Structure Erosion Control at Lower Bird Creek WWTP per these specifications.</td>
</tr>
<tr>
<td>21</td>
<td>203.700</td>
<td>All materials, labor, equipment, and supervision required for the VFD #2 and VFD #3 Replacements at the Interceptor LS at Northside WWTP per these specifications.</td>
</tr>
<tr>
<td>22</td>
<td>203.180</td>
<td>All materials, labor, equipment, and supervision required for the North Switch sitework at Northside WWTP per these specifications.</td>
</tr>
<tr>
<td>23</td>
<td>203.900</td>
<td>All materials, labor, equipment, and supervision required for the Digester 1 &amp; 2 Building Basement VFD #1 and #2 at Southside WWTP per these specifications.</td>
</tr>
</tbody>
</table>

END OF SECTION
200 INTRODUCTION

201 QUALIFICATION REQUIREMENTS

202 SUMMARY OF BID ITEMS

203 DESCRIPTION OF BID ITEMS/WORK

- 203.250 NS PEW Pump Controls Improvements
- 203.300 Roof Replacement
- 203.400 Polymer Blend System
- 203.620 Plant Painting
- 203.998 Mobilization
- 203.999 MEP

204 ANCILLARY EQUIPMENT & WORK

- 204.4 General Electrical
- 204.5 Painting
- 204.6 Concrete Coating
- 204.7 Concrete Rehabilitation
- 204.8 Cast In Place Concrete
- 204.9 Concrete Reinforcement
- 204.10 Construction Joints, Expansion Joints and Waterstops
- 204.11 Concrete Formwork

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208 SAFETY

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210 PROTECTION OF MATERIALS

211 REFERENCES TO OTHER SPECIFICATIONS

212 CLEAN-UP

213 PLACING WORK IN SERVICE

214 PAYMENT

END OF SPECIFICATIONS
<table>
<thead>
<tr>
<th></th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>203.700</td>
<td>Active Frontend Variable Frequency Drive Controllers (Interceptor LS)</td>
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<tr>
<td>203.730</td>
<td>Panel Board (NSWWTP Operations Building)</td>
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<tr>
<td>203.770</td>
<td>Automatic Transfer Switch (Port South LS)</td>
</tr>
<tr>
<td>203.820</td>
<td>Active Frontend Variable Frequency Drive (SSWWTP Effluent Pump Station)</td>
</tr>
<tr>
<td>203.860</td>
<td>Motor Control Centers (SSWWTP Effluent Pump Station)</td>
</tr>
<tr>
<td>203.900</td>
<td>Active Frontend Variable Frequency Drive (SSWWTP Digester 1-2)</td>
</tr>
</tbody>
</table>

(Remainder of Page Left Intentionally Blank)
203.250.1 All materials, labor, equipment and supervision required for control improvements to the existing PEW pump system.

203.250.2 The work located at the Northside WWTP, consists of the following scope of improvements:

203.250.2.1 For clarification, the WWTP Staff has recently replaced an existing Allen Bradley PanelView module (that provided an interface with the existing PEW pump skid PLC) with a panel mount touch screen PC. The new panel PC has current Wonderware software installed and is functioning as a full SCADA node. Integration services are needed to complete the installation as follows:

203.250.2.2 Provide Integration services to reconfigure existing PLC as required to interface with new PC. All existing PLC programming and functionality shall be retained.

203.100.2.3 Provide Integration services to develop and/or modify existing PEW HMI screens. Screens should at minimum graphicly display the following information:

- Run status (on/off/fail) for each pump
- Run time hour meter for each pump
- User adjustable discharge pressure set point and operation mode selection.

203.250.3 Project work shall include all materials, equipment, labor, and supervision necessary to complete the project as specified herein.

203.250.4 TESTING: The PEW system shall be tested under operating conditions in the presence of the Owner and Owner’s Representatives. Provide a total of 12 onsite hours for testing and training of Owners staff.

END OF SECTION
All materials, labor, equipment, and supervision required for installation of new roofing system and drain system improvements at the SSWWTP Digester 1-2 building per these specifications. The work and costs includes, but is not limited to new roofing membrane, build up rigid insulation, fascia, custom flashing to equipment/roof mounted items, vent flashing, coping rehabilitation, coordination with roof drains and new walk pads throughout. Other inclusions are includes protecting, coordinating and repairs to the lightning protection, along with rehabilitation and repairs to the roof parapet wall coping. **BID COSTS ALSO INCLUDE SPECIAL 15 YEAR WARRANTEE WITH CERTIFICATE TO THE CITY OF TULSA.** See Bid Proposal for base bid and alternate bid items.

The work consists of the following scope of improvements:

A. Demolition of the existing roofing systems complete, including but not limited to the roof system, ballast as applicable, insulation, flashing, trim, roof penetration flashing, fasteners, fascia or other component of the existing roofing systems for a complete replacement to new roofing system and warrantee.

B. Contractor shall provide new roofing system complete, including but not limited to the roof membrane, insulation, flashing, trim, roof penetration flashing, fasteners, fascia or other component of the roofing system for a complete replacement to new materials and warrantee.

C. Protection of existing roof decking, surface mounted equipment, skylights, vents and another roof mounted item.

D. Refer to Specification Section 204 for additional painting and preparation requirements.

Refer to Contract Drawings for additional information and details.

Project work shall include all materials, equipment, labor, and supervision necessary to complete the project as specified herein, including but not limited to any and all crane work, rigging, scaffolding, access to, work area safety and other items as required to provide a complete and functional installation.

Contractor shall submit work plan acceptable to the Engineer describing the duration and sequence of work. Plan shall be approved prior to commencement of work. Contractor shall coordinate this work with other work in order to minimize time equipment is out of service.
203.300.12 The Contractor shall install equipment and materials in a workmanlike manner utilizing craftsmen skilled in the particular trade. Installation practices shall conform to Manufacturer's recommendations.

203.300.5 Submit all materials for approval prior to work.

203.300.6 **Manufacture Product Warrantee:** Contractor shall coordinate, complete Manufacture form requirements and provide the City all final warrantee documentation. Payment for completed in place work shall be 90% of bid item cost and remaining 10% of bid item payment shall represent acceptable completed warrantee paperwork transmitted to the City, c/o Plant Superintendent.

203.300.7 **Contractor shall coordinate and provide a Manufacture's warrantee commencing on date of substantial completion, including costs for labor and materials for loss of water tightness without financial limit for a period of 15 years with a no dollar limit (NDL).**

203.300.8 Roofing TPO membrane roofing system or PVC membrane roof system shall be manufactured by Carlisle Syntec, Sure Flex PVC membrane roofing with mechanically fastened roofing system and new built up insulation, or approved equal. See contract drawings for requirements and details which govern over specification. All other accessories required for proper operation that meet the following specification:

- **Roof area(s):** Pump station roofs, see plan sheets.
- **Insulation** Carlisle HP-H Polyiso grade 3 or equal.
- **Walk mats** From each ladder access to and around equipment and items which require maintenance. Additional locations and paths are show on the contract plans.
- **Color of membrane** Standard color, white
- **Electrical improvements:** No new electrical, Provide new welded custom 316 stainless flashing. Custom welded corners. Any laps shall be 6” min and caulked with NP or equal.
- **Skylight(s):** No new skylights, Provide new welded custom 316 stainless flashing. Custom welded corners. Any laps shall be 6” min and caulked with NP or equal.
- Roof Mounted Mechanical: No new equipment. Provide new welded custom 316 stainless flashing. Custom welded corners. Any laps shall be 6" min and caulked with NP or equal.

- Plumbing Vents: Yes, Provide new neoprene rubber stainless flashing at all existing and new piping vent locations.

- Hardware/fastener all shall be 316 Stainless unless specifically specified otherwise. All fasteners exposed shall be caulked.

- Coping, Fascia edge system OMG extruded aluminum cleat TerminEdge Fascia and coping system or equal. Coordinate blocking with insulation and system requirements. Color shall be “Bronze” anodized heavy aluminum flashing.

- Exposed Parapet/Coping New unless shown on the plans otherwise. Work shown on contract plans. Reuse existing.

- Adhesives, primers, bonding Per Roofing System Membrane Manufacture requirements for this project application.

- Step treads (anti-slip steps) Step treads shall be provided to and from any and all ladders to any and all equipment. Step treads shall be laid out around all equipment for maintenance and any roof item requiring regular or periodic maintenance. Contractor to confirm existing equipment and general layout for submittal sketch for approval of the step tread paths as part of the material submittal package.

- Roof Drains See plan sheets.

- Lightning Protection Reconnect lightning protection with new fasteners as required. Protect existing system during construction. Replace cable hold down clips and glue to new
roofing system. Maintain system design and coordinate cables with existing routing and layout.

203.300.9 **TAGGING:** No tagging is required.

END OF SECTION
203.400  All materials, labor, equipment and supervision required for RDT Polymer System Improvements at the Southside Wastewater Treatment Plant, per these specifications.

203.400.1 The project located at the Southside Wastewater Treatment Plant, consists of demolition of one existing dry polymer feed unit and the installation of a new liquid polymer blend unit system. The project includes the correct and complete installation of new components specified herein in conformance with the manufacturer’s instructions and recommendations for installation, subsequent testing of the new units and ensuring all components are in proper operation.

203.400.2 The polymer blend unit is identified as S070-RDT1-PBU01 on Drawings 203.400.A, B and C. The work includes demolition of the existing units, installation of the new system, replacement of existing piping and valves, installation of a new ultra-sonic level transducers, blend tank mixers, integration services and other ancillary items.

203.400.3 The work includes demolition of an existing dry polymer feeder, S070-RDT1-PFS01, Work included is shown on Drawing 203.400.A.

203.400.4 An electrical disconnect shall be added to the system or incorporated within the units control panel. Refer to the General Electrical specification section 204.4 for requirements.

203.400.5 Electrical conduit leading to the existing polymer units may be reused to the greatest extent possible. If conduit extensions are required, materials shall meet the requirements of the General Electrical specification section 204.4. Existing wiring shall not be spliced and shall be replaced back to the closest point of termination.

203.400.6 Contractor shall be knowledgeable about and shall field verify all elevations and dimensions of existing piping, conduit, valves and equipment that in any way, directly or indirectly, relates to the removal of existing equipment and/or installation of new equipment. Work shall be based on field measurements. The Authority will make information on file that pertains to the existing equipment available for review.

203.400.7 Project work shall include all materials, equipment, labor, and supervision, necessary to complete the project as specified herein including, but not limited to, any and all crane work, rigging, delivery, clean-up and complete installation of components to fully operational and warrantable condition.
203.400.8 All work requiring flow stoppage or equipment removed from service must be scheduled 48 hours in advance with Plant Superintendent. Contractor shall have valves, temporary pumps and any other necessary materials and equipment required to complete the work at the installation site prior to flow stoppage. It is the contractor’s responsibility to prepare the impacted system and any related systems for disassembly. This includes closing of upstream/downstream valves and pumping down any reservoirs necessary.

203.400.9 Major components of the liquid polymer blending system to be supplied under this section shall include, but not be limited to, the following:

- One (1) Liquid polymer blending unit
- One (1) Allen Bradley MicroLogix based PLC control panel
- Two (2) IBC tote containment skids
- Two (2) Ultrasonic level sensors
- Two (2) Blended polymer storage tank mixers
- Spare parts and accessories
- Start-up and training services

203.400.10 SUBMITTALS: Submittals shall include the following information:

- Dimensional drawings as required for the installation.
- Electrical wiring diagrams as required for the installation.
- Installation instructions.
- Sufficient information on each component to show that the equipment meets this specification.

203.400.11 QUALITY ASSURANCE:

- Components and installation shall comply with the Uniform, Standard and National Building and Fire Codes.
- Pre-assemble and factory test system to ensure compliance with pressure and operational requirements.

203.400.12 WARRANTY REQUIREMENTS: The polymer blending system shall be covered by a TWO (2) year conventional warranty. The mixing chamber
shall be covered by a LIFETIME warranty covering the repair or replacement of the mixing chamber or any part of the mixing chamber which fails for any reason, excluding weather related or over pressure failures. In addition, the mixing chamber shall be warranted against plugging for any reason. If plugging occurs the mixing chamber shall be repaired or replaced at no cost to the owner. Metering pumps, options and accessories shall be covered by a conventional one year warranty. The full warranty shall be valid regardless of whether potable or non-potable dilution water having a high solid content, is used.

203.400.13 MANUFACTURERS:

203.400.13.1 Provide a polymer blending and feed system as manufactured by:

- USGI Chemical Feed, Inc. (DynaBlend)
- USGI Chemical Feed, Inc. (Polyblend)
- VeloDyne, Inc. (VeloBlend)
- Prominent Fluid Controls, Inc. (ProMix)
- Engineer approved equal.

The “or equal” clause shall be defined as a system which is a minimum five (5) years proven track record of providing performance at least equal to the specified equipment; with the types of polymers specified below as proven by actual field trials; a design which inherently provides an equal level of reliability and quality compared to the system specified and with equal accessibility of parts for the operation and maintenance.

203.400.13.2 Alternates: The manufacturer of alternate equipment shall submit with their bid a list of ten (10) installations, each at least five years in operation, which quantify the proposed alternate system’s ability to meet the above criteria. All variations to these specifications must be listed in the manufacturers proposed scope of supply submitted at time of bid. The drawings and specifications are based on DynaBlend Model L4. Contractor shall include in the bid, and shall be responsible for the costs of any changes to accommodate other equipment, including but not limited to structural, mechanical and electrical work. Contractor shall also pay any additional costs necessary for revisions
of drawings and or specifications by Engineer.

203.400.14 **DESIGN CRITERIA:**

- The polymer dilution/feed unit shall be capable of automatically metering, diluting, activating and feeding liquid polymer with water.

- The polymer dilution/feed unit shall be capable of producing polymer solution with polymer-to-water solution concentrations between 0.25% - 1.0%.

203.400.15 **PERFORMANCE REQUIREMENTS:** The liquid polymer blending unit shall automatically meter, mix and blend concentrated liquid polymers with dilution water.

  - The polymer input capacity of each unit shall be 0.0125 to 20 gph of concentrated polymer using a liquid concentrate pump.

  - Dilution water range shall be 12 to 1200 gph.

203.400.16 **SERVICE CONDITIONS:**

203.400.16.1 Dilution water supply pressure shall be a minimum of 35 psi greater than the mixing chamber discharge pressure.

203.400.16.2 Control panel supply voltage shall be 120 VAC.

203.400.17 **EQUIPMENT:**

203.400.17.1 **Multi-Zone Mixing Chamber**

203.400.17.1.1 A non-mechanical hydrodynamic blending device specifically designed to dilute and activate emulsion, dispersion and solution type polymer with viscosities up to 75,000 cps. and active contents up to 75%, shall be provided. Systems without a proven track record will all types of polymers described above will not be considered.

203.400.17.1.2 The liquid polymer activation chamber’s mixing energy shall be staged such that it provides for high, non-damaging mixing energy over the full operating range of the system which then dissipates through concentric chambers. The integral water control device, which shall also produce mixing energy by creating a pressure
drop across its orifice, shall be constructed of stainless steel and brass and shall be designed to allow orifice replacement without disassembly of any other part of the system. The system shall be designed for use with either potable or non-potable dilution water.

203.400.17.1.3 A mixing chamber drain valve with ½” fitting shall be provided and plumbed to the nearest floor drain. The mixing chamber shall have a maximum rated pressure of 150 psi.

203.400.17.1.4 Provide a bronze, adjustable-range pressure relief valve on mixing chamber with a range of 20 to 175 psi.

203.400.17.1.5 At no time shall polymer be exposed to excessive shear. System’s which are “retention time dependent”, a system which is prone to induce insufficient or excessive mixing energy depending on flow rate and the subsequent retention time in the mixing chamber, or which utilize conventional static mixers, mixing blocks, enductors or flash mixers, shall not be considered. All components that require periodic maintenance shall be readily accessible.

203.400.17.2 Check Valve: Provide a neat polymer check valve specifically designed to isolate neat polymer from dilution water. The valve shall be designed with an open, unobstructed path to the valve seat. The valve body shall be constructed of Teflon and the ball shall be stainless steel. The valve shall be readily accessible for cleaning and shall be easily disassembled. Conventional check valves, and or check valves that are installed inside the mixing chamber, or which require mixing chamber disassembly for servicing will not be accepted.

203.400.17.3 Dilution Water Control - The dilution water flow rate shall be monitored by a stainless steel turbine flow meter. The flow meter shall provide the ratio controller with a 4-20 mAdc or pulse signal representative of water flow rate. Unions shall be provided on the inlet and outlet of the flowmeter to allow easy removal for cleaning or inspection.

- Materials of construction: Meter body – Machined, cast, 316 stainless steel. Turbine – 316 stainless steel
- Unit shall have an electric solenoid valve for on/off control of total dilution water flow. Materials of Construction: Brass body, NBR Seal
The dilution water flow rate shall be manually adjusted through a flow control valve connected directly to the mixing chamber. Valve shall be constructed of PVC body, SS needle, and SS seat.

Dilution water differential pressure shall be monitored by an industrial duty differential pressure switch rated NEMA 4X with a range of 0-90 psig. Pressure switches with plastic construction or fittings and mechanically actuated flow switches shall not be acceptable. Differential pressure switch shall be United Electric model J21K-254-M900 or equal.

203.400.17.4 Pump

Unit shall have a neat polymer metering pump. Pump shall be a four (4) stage positive displacement, progressing cavity type. Rotor shall be 316 SS. Stator shall be fluoroelastomer. Pump shall have a packing seal.

Pump shall be driven by a ¼ HP (minimum), TEFC, 0-90 volt DC motor. Variable speed capability shall be provided by an SCR controller. Maximum speed of the pump shall not exceed 1750 RPM.

Provide a metering pump calibration assembly rigidly mounted to the system frame and sized to provide a one-minute drawdown at 100% pump capacity. The column shall be graduated in increments of 0.1 gallons/10mL. Supporting the calibration column with the polymer piping is not acceptable.

203.400.17.5 Controls: A control panel affixed to the system's frame shall be provided, rated NEMA 4X and constructed of FRP. The control panel shall consist of all switches, relays, indicator lights, LCD displays, and controllers and required herein. The control panel components shall be NEMA 4X. All skid-mounted electrical components interconnected to control panel shall terminate on terminal blocks. Terminal blocks shall be sized for 14 ga. Wire with terminal block numbers and a legend. Wires shall be neatly run through wire race-way and numbered with adhesive type labels.
• Main Power/system ON-OFF-REMOTE selector switch.
• NEMA 4X, panel-mounted, 10-turn potentiometer for local control of pump speed.

203.400.17.5.2 PLC and Interface

• Provide an Allen Bradley MicroLogix based control panel with a PanelView Plus graphic terminal sized appropriately for the application.

203.400.17.5.3 Local Manual: Water and metering pump feed rates are set manually.

203.400.17.5.4 Local Auto:

• Desired dilution water flow rate is adjusted manually.
• Desired solution concentration set point is entered manually.
• The ratio control module will automatically adjust the pump flow rate as required to maintain the desired set point and solution concentration.
• Desired Blended Polymer Storage tank is selected manually. Tank inlet and outlet valves are automatically opened and closed to place selected tank in service.
• System shuts off at High Level set point.

203.400.17.5.6 Remote Auto:

• Desired solution concentration set point is received as a 4-20 mAADC analog signal. Desired dilution water flow rate is adjusted manually and polymer pump follows a remote control signal.
• Desired dilution water flow rate is adjusted manually and polymer pump follows a remote control signal.
• Desired Blended Polymer Storage tank is selected manually. Tank inlet and outlet valves are automatically opened and closed to place selected tank in service.
• System starts/stops automatically in a batch fill mode
based on user adjustable storage tank level set points.

- System shuts off at High Level set point.

203.400.17.5.7 Alarms

- Loss of Dilution water Flow Alarm, Differential Pressure type, Metering pump goes to stand-by mode when low dilution water pressure occurs. The pump automatically restarts when pressure returns.
- Storage Tank Low Level Alarm.
- Storage Tank High Level Alarm. System stops at high Level Alarm.

203.400.18 MAINTENANCE

- Unit Shall be open from design to allow easy access to all components.
- Mixing chamber shall be easily disassembled and reassembled to allow access to all parts exposed to neat polymer.
- Polymer check valve shall be readily accessible. Check valves installed inside mixing chamber shall not be acceptable.

203.400.18 MATERIAL SPECIFICATIONS

203.400.18.1 Connections – Plumbing

- Dilution water inlet, 1.5” FNPT
- Neat polymer inlet, 1” FNPT
- Solution discharge, 1.5” FNPT

203.400.18.2 Connections – Electrical

- Standard, grounded male plug – 120/1/60, 15 amps max.
- Terminal blocks for interconnecting all skid-mounted electrical devices.
- Terminal blocks for all remote input and output signals.

203.400.18.3 Dimensions
203.400.18.3.1 Frame, 24" wide x 24" deep x 68" high (62x62x175 cm)

203.400.18.4 Materials of Construction

- The system’s frame shall be of rugged 304 stainless steel construction. No mild steel shall be used. The skid shall be constructed of 3/16” minimum 304 stainless steel. The frame shall be constructed of 3/16” angle or structural stainless steel tubing. The panel supporting the control panel shall be a minimum of 12 ga. Vertical frame members shall be gusseted. All pipe supports shall be stainless steel. The skid shall be designed for fork-lifting and shall have holes for mounting to concrete pad. The systems frame shall be designed for an integral dilution water booster pump in the event the plant's water system is incapable of providing sufficient dilution water pressure. Maximum system dimensions shall be per schedule above. Control panel shall be mounted in vertical position and at 60” high. Pump suction shall not exceed 18” from the skid base.

- Piping and valves shall be mounted with rigid pipe clamps. Fasteners required to mount components to system frame shall be minimum ¼-20.

- Dilution water plumbing shall be schedule 80 PVC. Hose shall be braided vinyl. Hose fittings shall be schedule 80 PVC. No nylon fittings shall be used.

203.400.18.4.1 Mixing chamber – 304 stainless steel.

203.400.19 INCLUDED ACCESSORIES

203.400.19.1 Ultrasonic Level Transmitter

203.400.19.1.1 Replace the two existing ultrasonic level transmitters on the existing blended polymer storage tanks. Match existing size, type and materials.

203.400.19.2 IBC Tote Containment Unit

203.400.19.2.1 Provide and install two IBC Tote Containment Units; each 100% polyethylene containment tub with heavy duty metal platform. 400 gallon secondary spill capacity. Platform accepts IBC units from 38” to 50” in width. 10,000 pound load capacity.
203.400.19.3 Blended Polymer Storage Tank Mixers

203.400.19.3.1 Replace the two existing mechanical shaft mixers on the existing blended polymer storage tanks. Match existing size, type and materials.

203.400.20 SPARE PARTS

- Supply the following spare parts
- Neat polymer pump spare parts kit.
- One (1) spare replacement for each size and type of valve or solenoid utilized in the system.

203.400.21 OPERATION AND MAINTENANCE MANUALS

- Principle of Operation
- Installation Instructions
- Description of Unit and Component Parts
- Operating Procedures
- Maintenance Procedures
- Safety Precautions

203.400.22 INSTALLATION: Contractor shall install the liquid polymer blending unit in accordance with the manufacturer’s shop drawings and instructions.

203.400.23 MANUFACTURER’S SERVICES

203.400.23.1 Minimum Service Requirements

- Certify proper installation.
- One eight-hour day on site for start-up, testing and operator training.

203.400.24 PIPING MODIFICATIONS: Contractor shall furnish and install new pipes, valves, hangers and all appurtenances necessary to complete the installation. Existing piping may be reused except where replacement is indicated on the drawings. Match existing valve type including operator style and materials.

203.400.25 TAGGING: New equipment shall be tagged from the manufacturer with a permanent and visible tag showing the new equipment number using the
City of Tulsa Equipment ID system. Refer to Specification Section 204.3.6 for requirements.

203.400.26 **FIELD TESTING:** Polymer Blend Unit system shall be installed in strict conformance with the manufacturer’s recommendations, which are to be submitted with the shop drawings. After completion of the installation, the equipment shall be tested by the Contractor under actual operating conditions. The test shall be conducted under the supervision of the manufacturer’s technical representative and in the presence of the owner’s representative. Three (3) copies of test results shall be submitted to the Engineer. The equipment manufacturer shall furnish the services of a factory field representative to inspect the installation, testing and start up the equipment.

END OF SECTION
203.620 All materials, labor, equipment, and supervision required for improvements (painting) to the existing piping in the Aeration Basin Pipe Galleries #1 (South, aka train 1-2) and #2 (North, aka train 3-4) at the City of Tulsa Southside Wastewater Treatment Plant, per these specifications, which shall include the following.

1. Complete surface preparation and Coating of the Plant Effluent Water (PEW), Non-potable water and potable water per contact drawings 204.620, including piping, supports, hanger supports, valves, operators (handles red), couplings and miscellaneous. The existing new backflow preventors on supply line entering the north gallery are not to be painted. Other powder coated valves or check valves will be painted unless requested not during the work by the Plant staff.

2. This specification section is a supplement to specification section 204. Any conflict or discrepancy between the two specification sections, this specification section will govern.

204.620.4 Colors and Markings: Existing piping shall be identified with lettering or tags designating the service of each piping system, shall be marked with flow directional arrows, and shall be color coded as found on Drawings WPC 19-3 214.7 A thru C, and as follows.

A. PEW System: All PEW System piping, valves, supports, operators, couplings and miscellaneous shall be color coded and marked as follows.

1. Color Coding: Topcoat shall be Purple (Pantone 522) per the Oklahoma Department of Environmental Quality (DEQ) Title 252, Chapter 656, Section 252:656-27-4. In addition, piping shall have orange bands that are six (6) inches wide and spaced along the pipe at five (5) foot intervals.

2. Lettering: The following language: “CAUTION: RECLAIMED WATER-DO NOT DRINK.” shall be provided on the pipe near the equipment served, adjacent to valves, at each branch or tee, and at least every 50 feet in straight runs of pipe and be per Department of Environmental Quality (DEQ) Title 252, Chapter 656, Section 252:656-27-4. Additionally, the capital letters, “PEW”, shall be centered at intervals evenly spaced between the “CAUTION: RECLAIMED WATER-DO NOT DRINK” language along straight runs and as possible at branches or tees. Lettering shall be painted or stenciled on piping. Lettering shall be white. Reference Table 1 for lettering size requirements.
3. **Flow Arrows:** PEW System piping shall not have flow arrows.

**B. WAS System:** All WAS System piping, valves, supports, operators, couplings and miscellaneous shall be color coded and marked as follows.

1. **Color Coding:** Topcoat shall be Tnemec Peach Tea (34BR) or equivalent color.

2. **Lettering:** Lettering shall be provided on the pipe near the equipment served, adjacent to valves, at each branch or tee, and at least every 50 feet in straight runs of pipe. Lettering shall be as on existing piping and as directed by Engineer. Lettering shall be painted or stenciled on piping. Lettering shall be white. Reference Table 1 for lettering size requirements.

3. **Flow Arrows:** Flow arrows shall be in the direction of flow and shall be located six inches from the lettering on the flow direction side (i.e. flow arrows shall point away from lettering). Flow arrows shall be white.

**C. Dewatering and Thickener Effluent Systems:** All Dewatering and Thickener Effluent System piping, valves, supports, operators, couplings and miscellaneous shall be color coded and marked as follows.

1. **Color Coding:** Topcoat shall be Tnemec Beige (44 BR) or equivalent color.

2. **Lettering:** Lettering shall be provided as directed by Engineer. Lettering shall be as on existing piping and as directed by Engineer. Lettering shall be painted or stenciled on piping. Lettering shall be black. Reference Table 1 for lettering size requirements.

3. **Flow Arrows:** Flow arrows shall be in the direction of flow and shall be located six inches from the lettering on the flow direction side (i.e. flow arrows shall point away from lettering). Flow arrows shall be black.

**D. Air Systems:** All Air System piping, valves, supports, operators, couplings and miscellaneous shall be color coded and marked as follows.

1. **Color Coding:** Topcoat shall be Spearmint Green/Safety (09SF) or equivalent color.

2. **Lettering:** Lettering shall be provided as directed by Engineer. Lettering shall be as on existing piping and as directed by Engineer. Lettering shall be painted or stenciled on piping. Lettering shall be black. Reference Table 1 for lettering size requirements.
3. Flow Arrows: Flow arrows shall be in the direction of flow and shall be located six inches from the lettering on the flow direction side (i.e. flow arrows shall point away from lettering). Flow arrows shall be black.

E. Drain Systems: All Drain System piping, valves, supports, operators, couplings and miscellaneous shall be color coded and marked as follows.

1. Color Coding: Topcoat shall be No. 2 Pencil (47GR) or equivalent color.

2. Lettering: Lettering shall be provided as directed by Engineer. Lettering shall be as on existing piping and as directed by Engineer. Lettering shall be painted or stenciled on piping. Lettering shall be white. Reference Table 1 for lettering size requirements.

3. Flow Arrows: Flow arrows shall be in the direction of flow and shall be located six inches from the lettering on the flow direction side (i.e. flow arrows shall point away from lettering). Flow arrows shall be white.

<table>
<thead>
<tr>
<th>Outside Pipe Diameter</th>
<th>Minimum Height of Letters</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/8 inch and smaller</td>
<td>Metal Tags – 1/4 inch</td>
</tr>
<tr>
<td>3/4 to 1-1/4 inches</td>
<td>1/2 inch</td>
</tr>
<tr>
<td>1-1/2 to 2 inches</td>
<td>3/4 inch</td>
</tr>
<tr>
<td>2-1/2 to 6 inches</td>
<td>1-1/4 inches</td>
</tr>
<tr>
<td>8 to 10 inches</td>
<td>2-1/2 inches</td>
</tr>
<tr>
<td>Over 10 inches</td>
<td>3-1/2 inches</td>
</tr>
</tbody>
</table>

204.620.5 Quality Assurance

A. Quality assurance procedures and practices shall be utilized to monitor all phases of surface preparation, application and inspection throughout the duration of the project. Procedures or practices not specifically defined herein may be utilized provided they meet recognized and accepted professional standards and are approved by the Engineer.

B. Surface preparation will be based upon comparison with “Pictorial Surface Preparation Standards for Painting Steel Surfaces” SSPC-Vis-1 and ASTM
Designation D2200; “Standard Methods of Evaluating Degree of Rusting on Painted Steel Surfaces: SSPC-Vis-1 and ASTM Designation D610; Visual Standard for Surfaces of New Steel Airblast Cleaned and Sand Abrasive.”

C. No coating or paint shall be applied: When the surrounding air temperature or the temperature of the surface to be coated or painted is below the minimum surface temperature for the products specified herein; or when the surrounding air temperature is wet or damp (5° F. or less) above the dew point; or when the air temperature is expected to drop below specified minimum temperature within six hours after application of coating. Dew point shall be measured by use of an instrument such as a Sling Psychrometer in conjunction with U. S. Department of Commerce Weather Bureau Psychrometric Tables. If above conditions are prevalent, coating or painting shall be delayed or postponed until conditions are favorable. The day's coating or painting shall be completed in time to permit the film sufficient drying time prior to damage by atmospheric conditions. When necessary for proper application, a temporary enclosure shall be erected and kept heated until the coating has fully cured.

Application of the first coat shall follow immediately after surface preparation and cleaning and before rust bloom occurs. Any cleaned areas not receiving first coat within this period shall be re-cleaned prior to application of first coat.

D. Thickness of coatings and paint over steel substrates shall be checked with a non-destructive, magnetic-type thickness gauge. Use an instrument such as a Tooke Gauge if a destructive tester is deemed necessary. The integrity of coated interior surfaces shall be tested with an approved inspection device. Non-destructive holiday detectors shall not exceed 67.5 volts nor shall destructive holiday detectors exceed the voltage recommended by the manufacturer of the coating system.

For thicknesses between 10 and 20 mils (250 microns and 500 microns) a non-sudsing type wetting agent, such as Kodak Photo-Flo, shall be added to the water prior to wetting the detector sponge. All pinholes shall be marked, repaired in accordance with the manufacturer's printed recommendations and retested. No pinholes or other irregularities will be permitted in the final coating.
E. The Contractor shall furnish, until final acceptance of coating and paint, inspection devices in good working condition for detection of holidays and measurement of dry film thickness of coating and paint. The Contractor shall also furnish U.S. Department of Commerce, National Bureau of Standards certified thickness gauges and certified instrumentation to test accuracy of holiday detectors.

Dry film thickness gauges and holiday detectors shall be made available for the Engineer's use at all times until final acceptance of application. All inspection and testing shall be witnessed by the Engineer. All inspection and testing, including daily weather conditions, shall be recorded and a copy turned in to the Engineer at the weekly progress meetings. The original shall be kept onsite for review.

F. Warranty inspection shall be conducted during the eleventh month following completion of all coating and painting work. All defective work shall be repaired in accordance with this specification and to the satisfaction of the Engineer/Owner.

G. The coating manufacturer shall observe the surface preparation, mixing and application of the coating systems and submit a written report of what has been observed and any additional recommendations.

H. The Contractor's coating and painting equipment shall be designed for application of material specified and shall be maintained in first class working condition. Compressors shall have suitable traps and filters to remove water and oils from the air. The Contractor's equipment shall be subject to approval of the Engineer.

204.620.6 PROTECTION OF PROPERTY

A. The protection of City, State and Government equipment, fences, gates, signs, and other City property is of prime importance, and if the same be damaged, destroyed or removed, they shall be repaired, replaced, or paid for by the Contractor. Disturbance to this property must first be approved by the agency that controls it.
B. No valve or other control on any utility main or building service line shall be operated for any purpose by the Contractor. Before painting any valve, the Contractor shall have the Engineer mark valves that shall not be painted to avoid having those valves “painted shut”.

C. At places where the Contractor’s operations are adjacent to, or crossing, the plane of railway, telegraph, telephone, electric, and gas lines, or water lines, sanitary sewers, and storm sewers, damage to which might result in expense, loss or inconvenience, work shall not be commenced until all arrangements necessary for the protection thereof have been made.

D. In the event the contractor in any way fails to comply with the requirement of protecting, repairing, and restoring of any utility or utility service, the Engineer may, upon forty-eight (48) hours notice, proceed to protect, repair, rebuild or otherwise restore such utility or utility service as may be deemed necessary, and the cost thereof will be deducted from any money due or which may become due the contractor pursuant to the terms of his contract.

204.620.7 PROTECTION OF MATERIALS

A. All materials and equipment delivered to the site of the work shall be adequately housed and protected against damage or deterioration according to standard accepted procedures. The Contractor shall keep his storage yards in good order, arrange his materials neatly, and protect them from damage.

B. All coatings and paints shall be stored in enclosed structures to protect them from weather and excessive heat or cold. Flammable coatings or paint must be stored to conform to City, County, State and Federal safety codes for flammable coating or paint materials. At all times coatings and paints shall be protected from freezing.

204.620.8 REFERENCES TO APPLICATION SPECIFICATIONS

A. Coating and paint application shall conform to the requirements of the Steel Structures Painting Council Paint Application Specifications SSPC-SPA1,
latest revision, for “Shop, Field and Maintenance Painting”, the American Water Works Association and the manufacturer of the coating and paint materials.

B. Thinning shall be permitted only as recommended by the manufacturer and approved by the Engineer.

C. Each application of coating or paint shall be applied evenly, free of brush marks, sags, runs, with no evidence of poor workmanship. Care shall be exercised to avoid lapping on glass or hardware. Coatings and paints shall be sharply cut to lines. Finished surfaces shall be free from defects or blemishes.

D. Protective coverings or drop cloths shall be used to protect floors, fixtures and equipment. Care shall be exercised to prevent coatings or paints from being spattered onto surfaces that are not to be coated or painted. The Contractor shall be responsible for correcting and repairing any damage resulting from its or its subcontractor’s operations. Surfaces from which materials cannot be removed satisfactorily shall be recoated or repainted as required to produce a finish satisfactory to the Engineer.

E. When two coats of coating or paint are specified, where possible, the first coat shall contain sufficient approved color additives to act as an indicator of coverage or the two coats must be of contrasting color.

F. Film thickness per coat specified in Section 214 or per the manufacturer’s specifications is the minimum required. If roller application is deemed necessary, the Contractor shall apply additional coats to achieve the specified thickness.

G. All material shall be applied as specified.

H. All welds and irregular surfaces shall receive a brush coat of the specific product prior to application of the first complete coat (stripe coat). In some cases, weld burs and share edges may require grinding or additional sanding.
A. Immediately upon completion of the work at the site location in the contract, the Contractor shall remove all excess materials, equipment, tools, and debris. Coating or paint spots, oil or stains upon adjacent surfaces shall be removed and the jobsite cleaned. All damage to surfaces resulting from the work of this section shall be cleaned, repaired, or refinished to the satisfaction of the Engineer at no cost to the Owner. Paint chips and all debris are to be collected and disposed of in accordance with all City, County, State and Federal regulations.

END OF SECTION
PART 1 - GENERAL

1.1 DESCRIPTION

A. This specification describes a complete adjustable speed AC drive (VFD) **WITH INTERNAL BYPASS** used to control the speed of NEMA design B induction motors used in areas where low harmonic content is desired or mandated.

B. The manufacturer shall supply the VFD and all necessary controls as herein specified.

C. The VFD shall be manufactured by a company with at least ten (10) years’ experience in the production of this type of equipment.

<table>
<thead>
<tr>
<th>Antero Tag No.</th>
<th>Amps</th>
<th>RPM</th>
<th>Power Supply Volts/Phase</th>
<th>HP</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>N106-LFT1-VFD01</td>
<td>477(field verify)</td>
<td>712</td>
<td>480/3</td>
<td>400 (field verify)</td>
<td>Size VFD at 115% motor nameplate Full Load Amps as a minimum, but shall match the continuous rating of existing VFD’s 3 &amp; 4 recently installed</td>
</tr>
<tr>
<td>N106-LFT1-VFD02</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1.2 QUALITY ASSURANCE

A. The VFD manufacturing facility shall be ISO 9001 and ISO 14001 certified.

B. All printed circuit boards shall be completely tested before being assembled into the complete VFD. The VFD shall be subjected to a functional test and load test. The load test shall be at full rated load, or cycled load.

C. The VFD manufacturer shall have an analysis laboratory to evaluate the failure of any component.

1.3 QUALIFICATIONS

A. The VFD shall meet the following specifications

1. UL 508A, 508C, or UL-61800-5 – Underwriter’s Laboratory.

2. CAN/CSA-C22 No. 14-M91 – Canadian Standards Association. The VFD shall be C-UL or CSA Listed and carry the appropriate mark.

4. The VFD shall comply with the following European Union’s CE directives. The VFD shall carry the CE mark.
   a. EMC Low Voltage Directive 73/23 EEC
   b. EMC Directive 89/336 EEC
   c. Machinery Directive 98/37 EC

B. Acceptable manufacturers
   1. Schneider Electric Altivar 680 Low Harmonic VFD utilizing 3-level Type Active Rectification with integrated power modules.
   2. VFDs that are manufactured by a third party and "brand labeled" shall not be acceptable.
   3. VFD power structures that are manufactured by a third party and “brand labeled” shall not be acceptable.
   4. The low harmonic VFD must use 3-level active rectification to be considered an "approved equal."
   5. AFE Units without 3-level PWM technology (if approved) will require motor dv/dt output filters and common mode noise filters.
   6. **VFD shall be provided with internal bypass.**

1.4 SUBMITTALS

A. The Submittals shall include the following information:
   1. Outline dimensions and weight
   2. Customer connection and power wiring diagrams
   3. Complete technical product description, including a complete list of options provided
   4. Harmonic test data for both utility and generator power sources demonstrating harmonic current distortion up to the 30th harmonic at VFD input terminals
   5. Compliance to IEEE 519 – Harmonic analysis for the particular jobsite including total current distortion. In case an alternative low harmonic solution is offered, the VFD manufacturer shall provide calculations, specific to the jobsite, showing that the total harmonic current distortion (TDD) at the Point of Common Coupling (PCC) is at or below THDi limits as recommended by IEEE 519- June 2014.

PART 2 - DESIGN

2.1 DESCRIPTION

A. The VFD shall be a solid-state, AC-to-AC inverter-controlled device using the latest insulated gate bipolar transistor (IGBT) technology.

B. The VFD shall be a 3-level Active Front End (AFE) AC drive that is designed to comply with standard IEEE 519-2014 when installed in a system that is already in compliance with the standard. A 3-level design shall be used to provide a low harmonic current load to the power system and to avoid introducing additional common mode noise to the motor. Passive harmonic filters shall be acceptable for motors less than 150hp in size provided the TDD is shown to be less than limits established by IEE 519-2014. The 2-level type design shall not be acceptable due to the additional common mode noise output from the VFD to the motor.
2.2 HARMONICS

A. The AFE low harmonic construction of the VFD shall not contribute any significant harmonics at the input terminals of the VFD shall contribute no more than 5% THDi at the input terminals.

B. All harmonic management devices must be internal to the VFD enclosure and supplied as a complete solution.

C. The VFD shall have an active line supply unit which controls the waveform of the input current and reduces the low order harmonic current drawn from the power line. Line currents and voltages shall be nearly sinusoidal. IGBTs shall be used in the rectified and inverter circuits.

D. Each input phase of the VFD shall incorporate a symmetrical inductor-capacitor-inductor (LCL) filter high frequency arranged in a T-configuration. The inductors are to be series power components that carry the full current of the VFD.

E. The input current to the VFD shall have a total harmonic content less than 5% of full rated capability at the input terminals of the VFD on a power system sized according to IEEE 519-2014, at line voltage unbalance up to 2%, and under all motor load conditions.

F. The VFD shall operate at a fundamental power factor .98 or higher on the supply side when operating above 20% of rated full load current.

G. The VFD’s design shall not compensate for existing harmonic content in the distribution system.

2.3 Ratings

A. The VFD shall be rated to operate from 3-phase power, 380 Vac to 480 Vac +10/-10%. The overvoltage trip level shall be a minimum of 30% over nominal, and the undervoltage trip level shall be a minimum of 35% under the nominal voltage.

B. The VFD shall be rated to operate at the following environmental operating conditions. Ambient temperature: 0 to 40 °C continuous. VFDs that can operate at 40 °C intermittently (during a 24-hour period) are not acceptable and must be oversized Altitude: 0 to 3300 feet above sea level without derating, less than 95% humidity, non-condensing. The VFD shall have the capability to operate up to 50 °C with derating.

C. The low harmonic ATV680 VFD shall be offered from 150 through 900 hp normal duty, and 125 through 700 hp heavy duty, in similar construction and operation, using the same 3-level topology. For motor power ratings less than 150 hp, the use of an Altivar Process ATV630 VFD with passive harmonic filter is required.

D. The VFD shall be rated to operate from input power of 48 to 63 Hz.

E. Output voltage and current ratings shall match the adjustable frequency operating requirements of standard NEMA design A or NEMA design B motors.

F. The normal duty overload current capacity shall be 110% of rated current for one (1) minute out of ten (10) minutes.

G. The heavy-duty overload current capacity shall be 150% of rated current for one (1) minute out of ten (10) minutes.
2.4 Construction

A. The VFD manufacturer shall provide a complete package, ready-to-install solution. Third party entities that use VFD controllers from others in their package designs are not acceptable.

B. The most efficient IGBT power technology shall be used. This technology shall be used for all power and voltage ranges offered by the manufacturer.

C. The VFD shall offer microprocessor based control logic that is isolated from power circuitry.

D. The VFD shall use the same main control board for all ratings.

E. Control interfaces shall remain consistent for all power ratings.

F. The VFD shall use active input modules that employ 3-level type active rectification.

G. The VFD shall be offered in UL Type 1 or UL Type 12.

H. VFDs at all power rating shall be of free-standing construction and shall include the following standard features both passive filter solutions and Active Front End systems.
   1. A circuit breaker with a combination AIC Rating of 100,000 amperes.
   2. Modular power modules in the cabinet for quick removal and replacement of individual modules. The modular construction also allows for adaptation of the enclosure unit to individual requirements. The modularity and accessibility of the drive components allow for servicing without relocation of the drive enclosure.
   3. To ensure fast and easy handling, all VFD shall have a modular power modules and heavy power components such as Inverter IGBT Line Filtering and third level bi-directional IGBT.

I. All options as shown on drawings and specified in Section XXX shall be furnished and mounted by the VFD manufacturer. All optional features shall carry all of the necessary certifications as described in Section 1.03. Field installed kits shall not affect the VFD’s certification.

2.5 Operator Interface

A. A detachable UL Type 12 / IP65 rated bi-color backlit graphical user interface terminal with keypad and capacitive wheel shall be provided for monitoring, annunciation, and configuration. The graphical display shall change to a red backlit color when an alarm occurs. The mechanical mounting for the user interface on the cabinet shall be done with a 22 mm hole.

B. A “Simply Start” menu for fast and easy commissioning shall be provided. Parameter setting shall be easily accessible and user friendly with plain text messaging and actual setting range.

C. The keypad shall be capable of providing password protection.

D. The user interface shall be capable of saving and downloading configurations of the VFDs, as well as importing them to other VFDs.

E. The user interface shall offer a mini USB port for mass storage or PC device connection.

F. The VFD shall have self-diagnostic capabilities to display alarms, errors, and warnings as they occur and shall be able to store into memory the last 15 messages, at minimum. These shall be accessible by PC maintenance tools or by web server, with flash record for data logging.
G. The VFD shall have a separate dedicated RS232 Modbus serial port for the keypad and shall allow for simultaneous use of a remote mounted keypad with RS485 serial communications network.

H. The displayed messages shall be in plain text.

I. The display of the control unit shall have the following features:
   1. During normal operation, one (1) line of the control panel shall display the speed reference, run/stop status, forward/reverse status, and local/remote status. The remaining three (3) lines of the display shall be programmable to display the values of any three (3) operating parameters. The selection shall include at least the following values:
      a. Speed/torque in percent (%), RPM, or user-scaled units
      b. Output frequency, voltage, current, and torque
      c. Input voltage, power, and kilowatt hours
      d. Heatsink temperature and DC bus voltage
      e. Status of discrete inputs and outputs
      f. Values of analog input and output signals
      g. Values of PID controller reference, feedback, and error signals

2.6 Protective Features

A. The VFD shall be UL 508 or UL61800-5-1 Listed for use on distribution systems.

B. The VFD shall have coordinated short-circuit rating designed to UL 508C or UL 61800-5-1 and NEMA ICS 7.1 short-circuit rating: [100] kAIC.

C. Voltage sag immunity per SEMI F47.

D. Upon power-up, the VFD shall automatically test for valid operation of memory, option module, loss of analog reference input, loss of communication, AC-to-DC power supply, control power, and the pre-charge circuit.

E. The VFD shall be protected against short circuits between output phases and ground and the logic and analog outputs.

F. The VFD shall have a selectable ride through function that will allow the logic to maintain control for a minimum of one (1) second without tripping.

G. The deceleration mode of the VFD shall be programmable for normal and trip conditions. The stop modes shall include freewheel stop and fast stop.

H. Upon loss of the analog process follower reference signal, the VFD shall trip and/or operate at a user-defined speed set by a software programmed speed setting or last speed.

I. The VFD shall integrate a protection against IGBT and heatsink overtemperature.

J. The VFD shall have solid-state thermal protection that is UL Listed and meets UL 508C / UL 508A as a Class 10 overload protection and meets IEC 947.

K. The VFD shall have a motor thermal memory retention function per UL requirements.

L. The VFD shall be able to protect the motor when temperature probes are connected.
M. The VFD shall be able to limit the motor surge limitation to twice the DC bus voltage. This must be accomplished by use of internal software. The VFD shall limit the motor surge limitation to a value of not more than twice the DC bus voltage.

N. The VFD shall provide the following IGBT protection circuits.
   1. IGBT overcurrent protection
   2. IGBT check up sequence
   3. IGBT check up sequence before PWM enable sequence
   4. IGBT overheat protection

O. The VFD shall provide VFD current protection.
   a. Phase short circuit protection
   b. Ground protection
   c. Overcurrent protection

P. The VFD shall provide VFD voltage error protection.
   a. Mains overvoltage protection
   b. Mains undervoltage protection
   c. DC Bus overvoltage protection
   d. DC Bus pre-charge protection

Q. The VFD shall provide VFD Thermal protection.
   a. VFD overtemperature protection
   b. Fan management
   c. Switching frequency management

R. The VFD shall provide internal error detection.

S. The VFD shall provide motor protection functions
   a. Motor output phase detection
   b. Motor surge voltage
   c. Motor overload detection
   d. Motor stall protection

T. The VFD shall provide application protection functions
   a. Catch on fly function
   b. Mains input phase lost protection
   c. Motor overspeed input protection
   d. Current limitation
   e. Power limitation
   f. Reverse inhibition
   g. Underload protection
   h. Overload protection
   i. External error management
   j. Loss of follower signal
   k. Thermal sensor management
   l. PID feedback
   m. Customer defined input

2.7 Control Interface:

A. The VFD shall interface with automation systems to monitor, control, display, and record data for use in processing reports. VFD settings shall be retained in the VFD's nonvolatile memory.

B. The speed command reference shall be selectable from the following sources:
1. I/O terminals
2. Communication network
3. Web server
4. Remote graphic display terminal

C. A minimum of the following standard inputs/outputs shall be provided to interface with control systems and instrumentation:
   1. Analog inputs: [3] programmable 0(4)-20 mA or 0-10 Vdc
      a. Two (2) analog inputs shall also be programmable for temperature sensors (PTC, PT100, PT1000, KTY84)
   2. Analog outputs: Two (2) programmable 0(4)-20 mA or 0-10 Vdc
   3. Discrete inputs: [6] programmable isolated logic inputs as either sink or source
      a. Two (2) discrete inputs shall also be programmable as 0-30 kHz pulse inputs
      b. Two (2) discrete inputs shall be dedicated to the Safe Torque Off safety function in accordance with IEC/EN 61508-1 SIL3
      a. One (1) discrete output shall be dedicated to product watchdog logic

D. Programmable analog inputs shall be able to be assigned the following parameters:
   1. Speed reference
   2. Summing reference
   3. Subtracting reference
   4. Multiplying reference
   5. Torque reference
   6. Torque limitation
   7. PID feedback
   9. PID speed reference
   10. Forced local reference

E. Programmable analog outputs shall be able to be assigned the following parameters:
   1. Motor current
   2. Motor frequency
   3. Motor torque (signed or unsigned)
   4. Motor power
   5. Motor voltage
   6. Output frequency (signed or unsigned)

F. Programmable discrete inputs shall be able to be assigned the following parameters:
   1. Run

G. Programmable discrete outputs shall be able to be assigned the following parameters:
   1. Ready
2. Drive running
3. Frequency reference attained

H. Safety Inputs
1. The VFD shall provide two (2) inputs dedicated to the Safe Torque Off (STO) safety function, which prohibits unintended equipment operation, in accordance with IEC/EN 61508-1 SIL3.
2. The VFD shall be compliant with EN13849 (PLe).
3. The VFD shall be compliant with “Safety of Machinery,” EN 954-1.
4. The VFD manufacturer shall provide the certified schematics and the list of devices in order to comply with IEC/EN 60204-1 stopping category 0 and 1.
5. The VFD shall integrate the safety contacts in compliance with EN-81 13.2.2.3.

2.8 Communications
A. The VFD shall provide at minimum one (1) Modbus and one (1) Ethernet Modbus TCP communication port.
   1. Ethernet IP or Modbus TCP, RJ45 dual port for daisy chain
B. VFD Ethernet ports shall be IPv6 compliant, allow for web server access, and provide network management via Simple Network Management Protocol, and clock synchronization.
C. The VFD shall provide an embedded web server for enhanced diagnostic, configuration, parameter access, and energy management. It shall be possible to create a user-defined custom dashboard for viewing VFD and process status through tables, charts, and graphical views. It shall be possible to export data in standard table format using the web server, for information about energy consumption as well as error and warning history.
D. The VFD shall be compliant with the Cyber Security Management ISA Secure / Achilles.
E. The VFD shall provide integration connectivity via:
   1. DHCP protocol for Fast Device Replacement
   2. DTM library in compliance with standard FDT technology

2.9 Control Functions and Configurations
A. The VFD shall be capable of accepting independent command and speed reference signals from:
   1. Terminals
   2. Modbus port
   3. Ethernet port
   4. Communication option card
   5. Keypad display.
B. The VFD shall provide a speed set-point function capable of:
   1. Maximum output frequency function
   2. Low and high speed scaling and limitation function
   3. Jump frequency
C. The VFD shall provide a Stop function capable of:
   1. Deceleration ramp on power loss

D. The VFD shall have an acceleration/deceleration, time-adjustable ramp function capable of:
   1. Ramp type: linear ramp, S shape ramp, with U or customized profile
   2. Ramp deceleration adaptation
   3. Ramp switching

E. Application programming dedicated to pumps
   1. The VFD shall provide pump control and monitoring functions
      a. Centrifugal pump characteristics and configurations
      b. Pump monitoring function in order to define the data relevant for the pump (for example, acceleration, low speed, and high speed)
      c. Application units function in order to define the units used in applications
      d. Pump cyclic start protection in order to protect the pump against too many restarts in a dedicated time period
      e. Multi-pump functions
   2. The VFD shall provide pump protection functions.
      a. Anti-jam function in order to remove automatically clogging substances from the pump impellers
      b. Pipe cleaning function in order to start the pump regularly to avoid sedimentation in pump impeller
      c. Cavitation pump protection
      d. Inlet protection in order to avoid system dry running
   3. The VFD shall provide application control functions.
      a. Stop and Go function in order to reduce consumption of the VFD in case the pump does not work
      b. Pulse input for connection to flow meter feedback
      c. Process control (PID) function in order to maintain a process at a given pressure or flow reference
      d. Flow limitation function in order to allow limiting the consumption of water
      e. Friction loss compensation function in order to compensate pressure losses in pipes due to friction
      f. Pipe Fill function in order to manage a smooth control during pipe filling and to lessen the affects of water hammer
      g. Sleep wake-up function in order to manage periods of the application when process demand is low and when it is not needed
      h. Low demand function in order to define periods of the application when process demand is low in order to save energy
      i. Jockey pump control function in order to start a jockey pump, during sleep period, to maintain emergency service pressure or demand, such as low water
      j. Sensor management in order to define how VFD inputs will be used to manage the pressure sensor or flow sensor
   4. The VFD shall provide application protection functions.
      a. High flow protection function in order to detect pipe burst or detect running outside normal working area
      b. Outlet pressure protection function in order to fix minimum and maximum pressure
   5. The VFD shall provide pump curve input to help optimize pump performance.
      a. Input and storage of the pump characteristics including five (5) points of the pump curve.
b. A best efficiency point (BEP) function in order to operate at maximum system efficiency and alarms to indicate deviation from BEP.

F. The VFD Supplier shall have Windows-based PC software for configuring and diagnosing the VFD. It shall be possible to set and modify parameters, control the VFD, read actual values, and make trend analysis using the software. The PC tools may be connected to the VFD by a wired or wireless connection.

G. The VFD shall display all faults in plain text and help screens shall be available to guide the user in troubleshooting. Codes are not acceptable.

H. The VFD shall provide a real time clock for time stamping detected errors.

I. The VFD shall display detected errors with QR codes to guide the user in the troubleshooting.

J. The VFD must provide LED lights to indicate its status such as Power On, Run, Fault condition, active communications.

K. The VFD must have the ability to dynamically display I/O status.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the VFD exterior and interior prior to installation. Report any damage and do not install any VFDs that are structurally, moisture, or mildew damaged.

B. Prior to locating the VFD at the planned installation site, ensure that the location is prepared for the installation and that the storage or operating condition requirements can be maintained. Verify that the installation space requirements are satisfied. Report any conditions that are detrimental to performance of the work. Proceed with installation only after detrimental conditions have been corrected.

C. Before, during, and after installation ensure that the VFD is protected from area construction activities and site contaminants.

3.2 INSTALLATION

A. Installation shall comply with manufacturer's instructions, drawings, and recommendations.

3.3 FIELD QUALITY CONTROL

A. Configuration and startup: Provide the services of a qualified factory-trained manufacturer’s representative to assist the installing contractor with the installation, configuration, and startup of each VFD. The manufacturer’s representative shall inspect the installation of each VFD prior to energizing and configure each VFD for operation under the specified conditions. The manufacturer’s representative shall conduct the initial startup and operation of each VFD. The manufacturer’s representative shall revisit the project site as often as necessary to ensure that all issues are corrected and that the installation and operation of the VFD are satisfactory.

B. Certification: The Contractor shall submit a written report certifying that each VFD has been installed, configured, and tested under load in accordance with the manufacturer’s recommendations. This report shall be signed by a factory-trained manufacturer’s representative and shall include a listing of all modifications and adjustments made on site to
include any settings/parameters that are not identified as factory defaults in the equipment's O&M documentation.

C. Specified products shall be tested as a system for conformance to specification requirements prior to scheduling the acceptance tests. The Contractor shall conduct performance verification tests in the presence of a Government representative, observing and documenting complete compliance of the system to the specifications. The Contractor shall submit a signed copy of the test results, certifying proper system operation before scheduling tests.

3.4 TRAINING

A. The services of a factory-trained instructor shall be provided for the purpose of training the Owner’s staff in the proper operation and maintenance of the VFDs. Training shall consist of not less than [1] session(s) with [4] hours of onsite classroom and hands-on instruction for a minimum of [4] attendees per session. The instructor shall provide sufficient time and detail in each session to cover the following as a minimum:

1. Theory of operation
2. Operation of VFDs furnished
3. Maintenance and configuration
4. Configurations of VFDs furnished
5. Troubleshooting and repair
6. Replacement of component level parts
PART 1 GENERAL

1.01. SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required and install all panelboards as shown on the Drawings and as specified herein.

1.02. REFERENCE STANDARDS

A. Panelboards shall be in accordance with the Underwriter Laboratories (UL) "Standard for Panelboards" and "Standard for Cabinets and Boxes" and shall be so labeled where procedures exist. Panelboards shall also comply with NEMA Standard for Panelboards and the National Electrical Code (NEC).

B. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.03. MANUFACTURERS

A. 120/240 Volt, single phase, 3 Wire and 120/208 Volt, 3 Phase, 4 Wire panelboards shall be Sentron Type P1 as manufactured by Siemens; Type NQOD by Square D Co.; Type Pow-R-Line C by Cutler-Hammer; or Type AQ as manufactured by the General Electric Co., Siemens

B. 277/480 Volt, 3 Phase, 4 Wire panelboards shall be Sentron Type P1 or P2 as manufactured by Siemens; Type NF by Square D Co.; Type Pow-R-Line C by Cutler-Hammer or Type AE as manufactured by the General Electric Co., Siemens

C. 480 Volt, 3 Phase, 3 Wire Power panelboards shall be Sentron Type P3 as manufactured by Siemens; Type NF by Square D Co.; Type Pow-R-Line C by Cutler-Hammer; or Type AD by General Electric Co., Siemens

D. 480 Volt, 3 Phase, 3 Wire Distribution panelboards shall be Sentron Type P4 or P5 as manufactured by Siemens; I-Line series by Square D Co. or Spectra Series by General Electric Co.; Type Pow-R-Line C by Cutler-Hammer, Siemens or equal.

E. NEMA 3, 4 and 12 panelboards shall be similar to those specified above with appropriate enclosure modifications as required by voltage application. Panel enclosures shall be provided as specified in Section 16000 and 16110.

PART 2 PRODUCTS

2.01. GENERAL

A. Rating

1. Panelboard ratings shall be as shown on the Drawings. All panelboards shall be rated for the intended voltage.
2. Circuit breaker panelboards shall be fully rated for the specified circuit breaker fault current interrupting capacity. Series connected short circuit ratings will not be acceptable.

2.02. MATERIALS (NEMA 1)

A. Interiors

1. All interiors shall be completely factory assembled with circuit breakers, wire connectors, etc. All wire connectors, except screw terminals, shall be of the anti-turn solderless type and all shall be suitable for copper or aluminum wire of the sizes indicated.

2. Interiors shall be so designed that circuit breakers can be replaced without disturbing adjacent units and without removing the main bus connectors and shall be so designed that circuits may be changed without machining, drilling or tapping.

3. Branch circuits shall be arranged using double row construction except when narrow column panels are indicated. Branch circuits shall be numbered by the manufacturer.

4. A nameplate shall be provided listing manufacturer's name, panel type and rating.

B. Buses

1. Bus bars for the mains shall be of copper. Full size neutral bars shall be included. Phase bussing shall be full height without reduction. Cross connectors shall be copper.

2. Neutral bussing shall have a suitable lug for each outgoing feeder requiring a neutral connection.

3. Spaces, provision for future breakers, shall have bus straps bolted onto the bus so that future breakers can be bolted into the panel.

4. Equipment ground bars shall be furnished.

C. Boxes

1. Recessed or flush mounted boxes shall be made from galvanized code gauge steel having multiple knockouts, unless otherwise noted. Boxes shall be of sufficient size to provide a minimum gutter space of 4-in on all sides.

2. Surface mounted boxes and trims shall have an internal and external finish as specified in Paragraph 2.04D4 below. Surface mounted boxes shall be field punched for conduit entrances.

3. At least four studs for mounting the panelboard interior shall be furnished.

D. Trim
1. Hinged doors covering all circuit breaker handles shall be included in all panel trims.
2. Doors shall have semi flush type cylinder lock and catch, except that doors over
   48-in in height shall have a vault handle and 3-point catch, complete with lock,
   arranged to fasten door at top, bottom and center. Door hinges shall be concealed.
   Furnish two keys for each lock. All locks shall be keyed alike; directory frame and
   card having a transparent cover shall be furnished on each door.
3. The trims shall be fabricated from code gauge sheet steel.
4. All exterior and interior steel surfaces of the panelboard shall be properly cleaned
   and finished with ANSI Z55.1, No. 61 light gray paint over a rust-inhibiting
   phosphatized coating. The finish paint shall be of a type to which field applied paint
   will adhere.
5. Trims for flush panels shall overlap the box by at least 3/4-in all around. Surface
   trims shall have the same width and height as the box. Trims shall be fastened with
   quarter turn clamps.
6. Door-in-door type construction shall be provided so that trim may be opened to
   access wire ways without removing the trim from the panel

2.03. CIRCUIT BREAKERS

A. Panelboards shall be equipped with circuit breakers with frame size and trip settings as
   shown on the Drawings.
B. Circuit breakers shall be molded case, bolt-in type.
C. Circuit breakers shall be as manufactured by the panelboard manufacturer.

PART 3 EXECUTION

3.01. INSTALLATION

A. Mount boxes for surface mounted panelboards so there is at least 1/2-in air space between
   the box and the wall.
B. Connect panelboard branch circuit loads so that the load is distributed as equally as
   possible between the phase busses.
C. Type circuit directories giving location and nature of load served. Install circuit directories
   in each panelboard.
D. Install markers on the front cover of all panelboards which identify the voltage rating.
   Markers shall be made of self sticking B-500 vinyl cloth printed with black characters on an
   Alert Orange background, 2-1/4-in high by 9-in wide, Style A as manufactured by W.H.
   Brady Co. or equal.
E. Install a 1-in by 3-in laminated plastic nameplate with 1/4-in white letters on a black background on each panelboard. Nameplate lettering shall be as shown on the Drawings. Nameplates shall be stainless steel screw mounted.

END OF SECTION
PART 1 GENERAL

1.01 Scope

Furnish and install an automatic transfer switch (ATS) rated 800 amperes, 3-pole with solid neutral, 277/480V, 3-phase and withstand current ratings as shown on the plans to provide complete automatic operation. All transfer switches and control panels shall be the product of the same manufacturer. **ATS shall be configured for dual utility sources, not emergency generator.**

1.02 Acceptable Manufacturers

Automatic transfer switches shall be Eaton ATC Series with ATC-300+ controller. Any alternate shall be submitted to the consulting engineer in writing at least 20 days prior to bid. Each alternate bid must list any deviations from this specification. **Eaton was selected due to space constraints, alternates are allowed but must meet installation requirements. Local contact RP Power 918-939-9759.**

1.03 Codes and Standards

The automatic transfer switches and accessories shall conform to the requirements of:

- UL 1008 - Standard for Automatic Transfer Switches
- CSA C22.2 No. 178-1978 – Canadian Standards Association
- UBC, BOCA Seismic Zone 4
- NFPA 70 - National Electrical Code
- NFPA 110 - Emergency and Standby Power Systems
- NEMA Standard ICS10-1993 - AC Automatic Transfer Switches
- NEC Articles 700, 701, 702

PART 2 PRODUCTS

2.01 Mechanically Held Transfer Switch

A. The transfer switch unit shall be electrically operated and mechanically held. The electrical operator shall be a solenoid mechanism, momentarily energized. Main operators which include over-current disconnect devices will not be accepted.

B. The switch shall be positively locked and unaffected by momentary outages so that contact pressure is maintained at a constant value and temperature rise at the contacts is minimized for maximum reliability and operating life.

C. All main contacts shall be silver composition and shall be protected by separate arcing contacts.

D. Inspection of all contacts shall be possible from the front of the switch without disassembly of operating linkages and without disconnection of power conductors. A manual operating handle shall be provided for maintenance purposes.
E. Designs utilizing components of molded-case circuit breakers, contactors, or parts thereof which are not intended for continuous duty, repetitive switching or transfer between two active power sources are not acceptable.

F. Where neutral conductors are to be solidly connected, a neutral terminal plate with fully-rated AL-CU pressure connectors shall be provided.

G. The ATS shall be 100% rated for 800 amps, at 480 volt, housed in a Nema 1 indoor enclosure. It shall be 3-pole with a solid neutral.

2.02 Microprocessor Controller with Membrane Interface Panel

A. The controller shall direct the operation of the transfer switch. The controller shall be connected to the transfer switch by an interconnecting wiring harness. The harness shall include a keyed disconnect plug to enable the controller to be disconnected from the transfer switch for routine maintenance.

B. Sensing and control logic shall be via microprocessor based logic, Eaton’s ATC-300+ or approved equal, with 2-line backlit LCD display, LED’s and pushbuttons as described in Section 3.03 A.

C. The controller shall meet or exceed the requirements of the following:

- UL 1008 – UL Standard for Safety for Transfer Switch Equipment
- UL 991 – UL Tests for Safety Related Controls Employing Solid-State Devices
- CSA 22.2 No. 178 – Canadian Standards Association
- IEC 61000-4-2, 4-3, 4-4, 4-5, 4-6, & 4-11 – International Electro-technical Commission EMC Standards

2.03 Enclosure

A. ATS shall be in a Nema 1 enclosure.

B. The ATS dimensions cannot exceed 79.5” tall x 25.25” wide x 22.5” deep.

PART 3 OPERATION

3.01 Source Sensing

A. The controller shall provide the following sensing of the normal source:

<table>
<thead>
<tr>
<th>Normal Source</th>
<th>Under Voltage</th>
<th>3 Phase Sensed</th>
<th>Adjustable 50% - 99%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal Source</td>
<td>Over Voltage</td>
<td>3 Phase Sensed</td>
<td>Adjustable 103% - 120%</td>
</tr>
<tr>
<td>Normal Source</td>
<td>Under Frequency</td>
<td>3 Phase Sensed</td>
<td>Adjustable 90% - 99%</td>
</tr>
<tr>
<td>Normal Source</td>
<td>Over Frequency</td>
<td>3 Phase Sensed</td>
<td>Adjustable 101% - 110%</td>
</tr>
<tr>
<td>Normal Source</td>
<td>Phase Reversal</td>
<td>3 Phase Sensed</td>
<td>Adjustable A-B-C or C-B-A</td>
</tr>
<tr>
<td>Normal Source</td>
<td>Voltage Unbalance</td>
<td>3 Phase Sensed</td>
<td>Adjustable 5% - 20%</td>
</tr>
</tbody>
</table>
B. The controller shall provide the following sensing of the emergency source:

<table>
<thead>
<tr>
<th>Emergency Source</th>
<th>Sensing</th>
<th>Phasing</th>
<th>Adjustable Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under Voltage</td>
<td>3 Phase Sensed</td>
<td>Adjustable 50% - 99%</td>
<td></td>
</tr>
<tr>
<td>Over Voltage</td>
<td>3 Phase Sensed</td>
<td>Adjustable 103% - 120%</td>
<td></td>
</tr>
<tr>
<td>Under Frequency</td>
<td>3 Phase Sensed</td>
<td>Adjustable 90% - 99%</td>
<td></td>
</tr>
<tr>
<td>Over Frequency</td>
<td>3 Phase Sensed</td>
<td>Adjustable 101% - 110%</td>
<td></td>
</tr>
<tr>
<td>Phase Reversal</td>
<td>3 Phase Sensed</td>
<td>Adjustable A-B-C or C-B-A</td>
<td></td>
</tr>
<tr>
<td>Voltage Unbalance</td>
<td>3 Phase Sensed</td>
<td>Adjustable 5% - 20%</td>
<td></td>
</tr>
</tbody>
</table>

3.02 Time Delays

A. The controller shall provide the following time delays:

<table>
<thead>
<tr>
<th>Time Delay</th>
<th>Adjustable Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine Start</td>
<td>0 – 120 Seconds</td>
</tr>
<tr>
<td>Transfer From Normal to Emergency</td>
<td>0 – 1800 Seconds</td>
</tr>
<tr>
<td>Transfer From Emergency to Normal</td>
<td>0 – 1800 Seconds</td>
</tr>
<tr>
<td>Engine Cool-down</td>
<td>0 – 1800 Seconds</td>
</tr>
<tr>
<td>Emergency Failure</td>
<td>0 – 6 Seconds</td>
</tr>
<tr>
<td>Neutral (3 Position Contactors)</td>
<td>0 – 120 Seconds</td>
</tr>
<tr>
<td>In Phase Monitor (2 Position Contactors)</td>
<td>Adjustable 0 – 3 Hz</td>
</tr>
<tr>
<td>In Phase Synchronization</td>
<td>0 – 3600 Seconds</td>
</tr>
</tbody>
</table>

3.03 Displays and User Interfaces:

A. The controller shall provide the following displays and user interfaces:

<table>
<thead>
<tr>
<th>Display</th>
<th>Sensor</th>
<th>User Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage on Normal Source</td>
<td>+/- 1.0%</td>
<td>Selectable VAC, VBC, &amp; VCA</td>
</tr>
<tr>
<td>Frequency on Normal Source</td>
<td>+/- 0.3 Hz</td>
<td></td>
</tr>
<tr>
<td>Voltage on Emergency Source</td>
<td>+/- 1.0%</td>
<td>Selectable VAC, VBC, &amp; VCA</td>
</tr>
<tr>
<td>Frequency on Emergency Source</td>
<td>+/- 0.3 Hz</td>
<td></td>
</tr>
<tr>
<td>System History</td>
<td>Backlit LCD</td>
<td>16 Events, Date / Time / Event</td>
</tr>
<tr>
<td>Engine Run Time</td>
<td>Backlit LCD</td>
<td>0-9999 Hours</td>
</tr>
<tr>
<td>Source 1 Connected Time</td>
<td>Backlit LCD</td>
<td>0-9999 Hours</td>
</tr>
<tr>
<td>Source 2 Connected Time</td>
<td>Backlit LCD</td>
<td>0-9999 Hours</td>
</tr>
<tr>
<td>Source 1 Available Time</td>
<td>Backlit LCD</td>
<td>0-9999 Hours</td>
</tr>
<tr>
<td>Source 2 Available Time</td>
<td>Backlit LCD</td>
<td>0-9999 Hours</td>
</tr>
<tr>
<td>Load Energized Time</td>
<td>Backlit LCD</td>
<td>0-9999 Hours</td>
</tr>
<tr>
<td>Total Number of Transfers</td>
<td>Backlit LCD</td>
<td>0-9999 Transfers</td>
</tr>
<tr>
<td>Normal Source Available</td>
<td>LED</td>
<td>White</td>
</tr>
<tr>
<td>Normal Source Connected</td>
<td>LED</td>
<td>Green</td>
</tr>
<tr>
<td>Emergency Source Available</td>
<td>LED</td>
<td>Amber</td>
</tr>
<tr>
<td>Emergency Source Connected</td>
<td>LED</td>
<td>Red</td>
</tr>
</tbody>
</table>
### FY’20 Water Pollution Control Capital Equipment Replacements TMUA Project No. WPC 20-1

<table>
<thead>
<tr>
<th>Description</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Password Protection</td>
<td>Pushbutton – 4 Digits</td>
</tr>
<tr>
<td>Bypass Time Delays</td>
<td>Pushbutton – TDNE &amp; TDEN</td>
</tr>
<tr>
<td>System Test</td>
<td>Pushbutton – Adjustable Load or No Load</td>
</tr>
<tr>
<td>Generator Start Contacts</td>
<td>Form A – (1) Set 5 Amp, 250VAC / 30VDC</td>
</tr>
<tr>
<td>Normal Connected Contacts</td>
<td>Form A – (1) Set 10 Amp, 250VAC / 30VDC</td>
</tr>
<tr>
<td>Emergency Connected Contacts</td>
<td>Form A – (1) Set 10 Amp, 250VAC / 30VDC</td>
</tr>
<tr>
<td>Normal Available Contacts</td>
<td>Form A – (1) Set 10 Amp, 250VAC / 30VDC</td>
</tr>
<tr>
<td>Emergency Available Contacts</td>
<td>Form A – (1) Set 10 Amp, 250VAC / 30VDC</td>
</tr>
<tr>
<td>Transfer Failure Contacts</td>
<td>Form A – (1) Set 10 Amp, 250VAC / 30VDC</td>
</tr>
<tr>
<td>Pre-Transfer Contacts</td>
<td>Form A – (1) Set 10 Amp, 250VAC / 30VDC</td>
</tr>
<tr>
<td>Go to Emergency Contacts</td>
<td>Form A – (1) Set 10 Amp, 250VAC / 30VDC</td>
</tr>
<tr>
<td>ATS Alarm Contacts Indicating:</td>
<td>Form A – (1) Set 10 Amp, 250VAC / 30VDC</td>
</tr>
<tr>
<td>* Failure to Close in 6 Seconds</td>
<td></td>
</tr>
<tr>
<td>* Operator Failure</td>
<td></td>
</tr>
<tr>
<td>* Lockout Condition</td>
<td></td>
</tr>
<tr>
<td>* Failsafe Condition</td>
<td></td>
</tr>
<tr>
<td>* Unsuccessful Engine Test</td>
<td></td>
</tr>
<tr>
<td>* Unsuccessful Exerciser Test</td>
<td></td>
</tr>
<tr>
<td>* Unsuccessful In Phase Transition</td>
<td></td>
</tr>
</tbody>
</table>

### 3.04 Exerciser Clock:

A. The controller shall include an exerciser clock with the following features:

<table>
<thead>
<tr>
<th>Description</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Password Protection</td>
<td>Pushbutton – 4 Digits</td>
</tr>
<tr>
<td>Exercise Interval</td>
<td>Adjustable Daily, 7, 14, or 28 Days</td>
</tr>
<tr>
<td>Exercise Duration</td>
<td>Adjustable 0 – 600 Minutes</td>
</tr>
<tr>
<td>Exercise Mode</td>
<td>Adjustable Load or No Load</td>
</tr>
<tr>
<td>Load Protection</td>
<td>Failsafe Sensing on Emergency Source</td>
</tr>
</tbody>
</table>

### PART 4 ADDITIONAL REQUIREMENTS

#### 4.01 Withstand and Closing Ratings

A. Withstand and closing ratings of the ATS shall be as follows (480 VAC) per UL1008:

<table>
<thead>
<tr>
<th>ATS Size</th>
<th>With Any Circuit Breaker per UL1008</th>
<th>With Specific Circuit Breaker per UL1008</th>
</tr>
</thead>
<tbody>
<tr>
<td>800A</td>
<td>50,000A</td>
<td>65,000A</td>
</tr>
</tbody>
</table>

#### 4.02 Tests and Certification

A. The complete ATS shall be factory tested to ensure proper operation of the individual components and correct overall sequence of operation and to ensure that the
operating transfer time, voltage, frequency and time delay settings are in compliance with the specification requirements.

B. Upon request, the manufacturer shall provide printed documentation certifying compliance with all of the requirements of this specification including compliance with the above codes and standards, and withstand and closing ratings. The certification shall identify, by serial number(s), the equipment involved. No exceptions to the specifications, other than those stipulated at the time of the submittal, shall be included in the certification.

4.03 Service Representation

A. The ATS manufacturer shall maintain a national service organization of company-employed personnel located throughout the contiguous United States. The service center’s personnel must be factory trained and must be on call 24 hours a day, 365 days a year.

B. The manufacturer shall maintain records of each switch, by serial number, for a minimum of 20 years.

C. For ease of maintenance, the transfer switch nameplate shall include drawing numbers and serviceable part numbers.
PART 1 - GENERAL

1.1 DESCRIPTION

A. This specification describes a complete adjustable speed AC drive (VFD) WITH INTERNAL BYPASS used to control the speed of NEMA design B induction motors used in areas where low harmonic content is desired or mandated.

B. The manufacturer shall supply the VFD and all necessary controls as herein specified.

C. The VFD shall be manufactured by a company with at least ten (10) years’ experience in the production of this type of equipment.

| Performance Data |
|---|---|---|---|
| | Amps | RPM | Power Supply Volts/Phase | HP |
| | 74 (field verify) | 1800 | 480/3 | 60 (field verify) |
| Remarks | Size VFD at 125% motor nameplate Full Load Amps as a minimum |

1.2 QUALITY ASSURANCE

A. The VFD manufacturing facility shall be ISO 9001 and ISO 14001 certified.

B. All printed circuit boards shall be completely tested before being assembled into the complete VFD. The VFD shall be subjected to a functional test and load test. The load test shall be at full rated load, or cycled load.

C. The VFD manufacturer shall have an analysis laboratory to evaluate the failure of any component.

1.3 QUALIFICATIONS

A. The VFD shall meet the following specifications

1. UL 508A, 508C, or UL-61800-5 – Underwriter’s Laboratory.

2. CAN/CSA-C22 No. 14-M91 – Canadian Standards Association. The VFD shall be C-UL or CSA Listed and carry the appropriate mark.

4. The VFD shall comply with the following European Union’s CE directives. The VFD shall carry the CE mark.
   a. EMC Low Voltage Directive 73/23 EEC
   b. EMC Directive 89/336 EEC
   c. Machinery Directive 98/37 EC

B. Acceptable manufacturers
1. Schneider Electric Altivar 680 Low Harmonic VFD utilizing 3-level Type Active Rectification with integrated power modules.
2. VFDs that are manufactured by a third party and “brand labeled” shall not be acceptable.
3. VFD power structures that are manufactured by a third party and “brand labeled” shall not be acceptable.
4. The low harmonic VFD must use 3-level active rectification to be considered an “approved equal.”
5. AFE Units without 3-level PWM technology (if approved) will require motor dv/dt output filters and common mode noise filters.
6. **VFD shall be provided with internal bypass.**

1.4 **SUBMITTALS**

A. The Submittals shall include the following information:
1. Outline dimensions and weight
2. Customer connection and power wiring diagrams
3. Complete technical product description, including a complete list of options provided
4. Harmonic test data for both utility and generator power sources demonstrating harmonic current distortion up to the 30th harmonic at VFD input terminals
5. Compliance to IEEE 519 – Harmonic analysis for the particular jobsite including total current distortion. In case an alternative low harmonic solution is offered, the VFD manufacturer shall provide calculations, specific to the jobsite, showing that the total harmonic current distortion (TDD) at the Point of Common Coupling (PCC) is at or below THDi limits as recommended by IEEE 519- June 2014.

PART 2 - DESIGN

2.1 **DESCRIPTION**

A. The VFD shall be a solid-state, AC-to-AC inverter-controlled device using the latest insulated gate bipolar transistor (IGBT) technology.

B. The VFD shall be a 3-level Active Front End (AFE) AC drive that is designed to comply with standard IEEE 519-2014 when installed in a system that is already in compliance with the standard. A 3-level design shall be used to provide a low harmonic current load to the power system and to avoid introducing additional common mode noise to the motor. Passive harmonic filters shall be acceptable for motors less than 150hp in size provided the TDD is shown to be less than limits established by IEE 519-2014. The 2-level type design shall not be acceptable due to the additional common mode noise output from the VFD to the motor.
2.2 HARMONICS

A. The AFE low harmonic construction of the VFD shall not contribute any significant harmonics at the input terminals of the VFD shall contribute no more than 5% THDi at the input terminals.

B. All harmonic management devices must be internal to the VFD enclosure and supplied as a complete solution.

C. The VFD shall have an active line supply unit which controls the waveform of the input current and reduces the low order harmonic current drawn from the power line. Line currents and voltages shall be nearly sinusoidal. IGBTs shall be used in the rectified and inverter circuits.

D. Each input phase of the VFD shall incorporate a symmetrical inductor-capacitor-inductor (LCL) filter high frequency arranged in a T-configuration. The inductors are to be series power components that carry the full current of the VFD.

E. The input current to the VFD shall have a total harmonic content less than 5% of full rated capability at the input terminals of the VFD on a power system sized according to IEEE 519-2014, at line voltage unbalance up to 2%, and under all motor load conditions.

F. The VFD shall operate at a fundamental power factor .98 or higher on the supply side when operating above 20% of rated full load current.

G. The VFD’s design shall not compensate for existing harmonic content in the distribution system.

2.3 Ratings

A. The VFD shall be rated to operate from 3-phase power, 380 Vac to 480 Vac +10/-10%. The overvoltage trip level shall be a minimum of 30% over nominal, and the undervoltage trip level shall be a minimum of 35% under the nominal voltage.

B. The VFD shall be rated to operate at the following environmental operating conditions. Ambient temperature: 0 to 40 °C continuous. VFDs that can operate at 40 °C intermittently (during a 24-hour period) are not acceptable and must be oversized Altitude: 0 to 3300 feet above sea level without derating, less than 95% humidity, non-condensing. The VFD shall have the capability to operate up to 50 °C with derating.

C. The low harmonic ATV680 VFD shall be offered from 150 through 900 hp normal duty, and 125 through 700 hp heavy duty, in similar construction and operation, using the same 3-level topology. For motor power ratings less than 150 hp, the use of an Altivar Process ATV630 VFD with passive harmonic filter is required.

D. The VFD shall be rated to operate from input power of 48 to 63 Hz.

E. Output voltage and current ratings shall match the adjustable frequency operating requirements of standard NEMA design A or NEMA design B motors.

F. The normal duty overload current capacity shall be 110% of rated current for one (1) minute out of ten (10) minutes.

G. The heavy-duty overload current capacity shall be 150% of rated current for one (1) minute out of ten (10) minutes.
2.4 Construction

A. The VFD manufacturer shall provide a complete package, ready-to-install solution. Third party entities that use VFD controllers from others in their package designs are not acceptable.

B. The most efficient IGBT power technology shall be used. This technology shall be used for all power and voltage ranges offered by the manufacturer.

C. The VFD shall offer microprocessor based control logic that is isolated from power circuitry.

D. The VFD shall use the same main control board for all ratings.

E. Control interfaces shall remain consistent for all power ratings.

F. The VFD shall use active input modules that employ 3-level type active rectification.

G. The VFD shall be offered in UL Type 1 or UL Type 12.

H. VFDs at all power rating shall be of free-standing construction and shall include the following standard features both passive filter solutions and Active Front End systems.
   1. A circuit breaker with a combination AIC Rating of 100,000 amperes.
   2. Modular power modules in the cabinet for quick removal and replacement of individual modules. The modular construction also allows for adaptation of the enclosure unit to individual requirements. The modularity and accessibility of the drive components allow for servicing without relocation of the drive enclosure.
   3. To ensure fast and easy handling, all VFD shall have a modular power modules and heavy power components such as Inverter IGBT Line Filtering and third level bi-directional IGBT.

I. All options as shown on drawings and specified in Section XXX shall be furnished and mounted by the VFD manufacturer. All optional features shall carry all of the necessary certifications as described in Section 1.03. Field installed kits shall not affect the VFD’s certification.

2.5 Operator Interface

A. A detachable UL Type 12 / IP65 rated bi-color backlit graphical user interface terminal with keypad and capacitive wheel shall be provided for monitoring, annunciation, and configuration. The graphical display shall change to a red backlit color when an alarm occurs. The mechanical mounting for the user interface on the cabinet shall be done with a 22 mm hole.

B. A “Simply Start” menu for fast and easy commissioning shall be provided. Parameter setting shall be easily accessible and user friendly with plain text messaging and actual setting range.

C. The keypad shall be capable of providing password protection.

D. The user interface shall be capable of saving and downloading configurations of the VFDs, as well as importing them to other VFDs.

E. The user interface shall offer a mini USB port for mass storage or PC device connection.
F. The VFD shall have self-diagnostic capabilities to display alarms, errors, and warnings as they occur and shall be able to store into memory the last 15 messages, at minimum. These shall be accessible by PC maintenance tools or by web server, with flash record for data logging.

G. The VFD shall have a separate dedicated RS232 Modbus serial port for the keypad and shall allow for simultaneous use of a remote mounted keypad with RS485 serial communications network.

H. The displayed messages shall be in plain text.

I. The display of the control unit shall have the following features:

1. During normal operation, one (1) line of the control panel shall display the speed reference, run/stop status, forward/reverse status, and local/remote status. The remaining three (3) lines of the display shall be programmable to display the values of any three (3) operating parameters. The selection shall include at least the following values:
   a. Speed/torque in percent (%), RPM, or user-scaled units
   b. Output frequency, voltage, current, and torque
   c. Input voltage, power, and kilowatt hours
   d. Heatsink temperature and DC bus voltage
   e. Status of discrete inputs and outputs
   f. Values of analog input and output signals
   g. Values of PID controller reference, feedback, and error signals

2.6 Protective Features

A. The VFD shall be UL 508 or UL61800-5-1 Listed for use on distribution systems.

B. The VFD shall have coordinated short-circuit rating designed to UL 508C or UL 61800-5-1 and NEMA ICS 7.1 short-circuit rating:[100] kAIC.

C. Voltage sag immunity per SEMI F47.

D. Upon power-up, the VFD shall automatically test for valid operation of memory, option module, loss of analog reference input, loss of communication, AC-to-DC power supply, control power, and the pre-charge circuit.

E. The VFD shall be protected against short circuits between output phases and ground and the logic and analog outputs.

F. The VFD shall have a selectable ride through function that will allow the logic to maintain control for a minimum of one (1) second without tripping.

G. The deceleration mode of the VFD shall be programmable for normal and trip conditions. The stop modes shall include freewheel stop and fast stop.

H. Upon loss of the analog process follower reference signal, the VFD shall trip and/or operate at a user-defined speed set by a software programmed speed setting or last speed.

I. The VFD shall integrate a protection against IGBT and heatsink overtemperature.

J. The VFD shall have solid-state thermal protection that is UL Listed and meets UL 508C / UL 508A as a Class 10 overload protection and meets IEC 947.
K. The VFD shall have a motor thermal memory retention function per UL requirements.

L. The VFD shall be able to protect the motor when temperature probes are connected.

M. The VFD shall be able to limit the motor surge limitation to twice the DC bus voltage. This must be accomplished by use of internal software. The VFD shall limit the motor surge limitation to a value of not more than twice the DC bus voltage.

N. The VFD shall provide the following IGBT protection circuits.
   1. IGBT overcurrent protection
   2. IGBT check up sequence
   3. IGBT check up sequence before PWM enable sequence
   4. IGBT overheat protection

O. The VFD shall provide VFD current protection.
   a. Phase short circuit protection
   b. Ground protection
   c. Overcurrent protection

P. The VFD shall provide VFD voltage error protection.
   a. Mains overvoltage protection
   b. Mains undervoltage protection
   c. DC Bus overvoltage protection
   d. DC Bus pre-charge protection

Q. The VFD shall provide VFD Thermal protection.
   a. VFD overtemperature protection
   b. Fan management
   c. Switching frequency management

R. The VFD shall provide internal error detection.

S. The VFD shall provide motor protection functions
   a. Motor output phase detection
   b. Motor surge voltage
   c. Motor overload detection
   d. Motor stall protection

T. The VFD shall provide application protection functions
   a. Catch on fly function
   b. Mains input phase lost protection
   c. Motor overspeed input protection
   d. Current limitation
   e. Power limitation
   f. Reverse inhibition
   g. Underload protection
   h. Overload protection
   i. External error management
   j. Loss of follower signal
   k. Thermal sensor management
   l. PID feedback
   m. Customer defined input
2.7 Control Interface:

A. The VFD shall interface with automation systems to monitor, control, display, and record data for use in processing reports. VFD settings shall be retained in the VFD's nonvolatile memory.

B. The speed command reference shall be selectable from the following sources:
   1. I/O terminals
   2. Communication network
   3. Web server
   4. Remote graphic display terminal

C. A minimum of the following standard inputs/outputs shall be provided to interface with control systems and instrumentation:
   1. Analog inputs: [3] programmable 0(4)-20 mA or 0-10 Vdc
      a. Two (2) analog inputs shall also be programmable for temperature sensors (PTC, PT100, PT1000, KTY84)
   2. Analog outputs: Two (2) programmable 0(4)-20 mA or 0-10 Vdc
   3. Discrete inputs: [6] programmable isolated logic inputs as either sink or source
      a. Two (2) discrete inputs shall also be programmable as 0-30 kHz pulse inputs
      b. Two (2) discrete inputs shall be dedicated to the Safe Torque Off safety function in accordance with IEC/EN 61508-1 SIL3
      a. One (1) discrete output shall be dedicated to product watchdog logic

D. Programmable analog inputs shall be able to be assigned the following parameters:
   1. Speed reference
   2. Summing reference
   3. Subtracting reference
   4. Multiplying reference
   5. Torque reference
   6. Torque limitation
   7. PID feedback
   9. PID speed reference
   10. Forced local reference

E. Programmable analog outputs shall be able to be assigned the following parameters:
   1. Motor current
   2. Motor frequency
   3. Motor torque (signed or unsigned)
   4. Motor power
   5. Motor voltage
   6. Output frequency (signed or unsigned)
F. Programmable discrete inputs shall be able to be assigned the following parameters:
   1. Run

G. Programmable discrete outputs shall be able to be assigned the following parameters:
   1. Ready
   2. Drive running
   3. Frequency reference attained

H. Safety Inputs
   1. The VFD shall provide two (2) inputs dedicated to the Safe Torque Off (STO) safety function, which prohibits unintended equipment operation, in accordance with IEC/EN 61508-1 SIL3.
   2. The VFD shall be compliant with EN13849 (PL e).
   3. The VFD shall be compliant with “Safety of Machinery,” EN 954-1.
   4. The VFD manufacturer shall provide the certified schematics and the list of devices in order to comply with IEC/EN 60204-1 stopping category 0 and 1.
   5. The VFD shall integrate the safety contacts in compliance with EN-81 13.2.2.3.

2.8 Communications

A. The VFD shall provide at minimum one (1) Modbus and one (1) Ethernet Modbus TCP communication port.
   1. Ethernet IP or Modbus TCP, RJ45 dual port for daisy chain

B. VFD Ethernet ports shall be IPv6 compliant, allow for web server access, and provide network management via Simple Network Management Protocol, and clock synchronization.

C. The VFD shall provide an embedded web server for enhanced diagnostic, configuration, parameter access, and energy management. It shall be possible to create a user-defined custom dashboard for viewing VFD and process status through tables, charts, and graphical views. It shall be possible to export data in standard table format using the web server, for information about energy consumption as well as error and warning history.

D. The VFD shall be compliant with the Cyber Security Management ISA Secure / Achilles.

E. The VFD shall provide integration connectivity via:
   1. DHCP protocol for Fast Device Replacement
   2. DTM library in compliance with standard FDT technology

2.9 Control Functions and Configurations

A. The VFD shall be capable of accepting independent command and speed reference signals from:
   1. Terminals
   2. Modbus port
3. Ethernet port  
4. Communication option card  
5. Keypad display.

B. The VFD shall provide a speed set-point function capable of:  
   1. Maximum output frequency function  
   2. Low and high speed scaling and limitation function  
   3. Jump frequency

C. The VFD shall provide a Stop function capable of:  
   1. Deceleration ramp on power loss

D. The VFD shall have an acceleration/deceleration, time-adjustable ramp function capable of:  
   1. Ramp type: linear ramp, S shape ramp, with U or customized profile  
   2. Ramp deceleration adaptation  
   3. Ramp switching

E. Application programming dedicated to pumps  
   1. The VFD shall provide pump control and monitoring functions  
      a. Centrifugal pump characteristics and configurations  
      b. Pump monitoring function in order to define the data relevant for the pump (for example, acceleration, low speed, and high speed)  
      c. Application units function in order to define the units used in applications  
      d. Pump cyclic start protection in order to protect the pump against too many restarts in a dedicated time period  
      e. Multi-pump functions  
   2. The VFD shall provide pump protection functions.  
      a. Anti-jam function in order to remove automatically clogging substances from the pump impellers  
      b. Pipe cleaning function in order to start the pump regularly to avoid sedimentation in pump impeller  
      c. Cavitation pump protection  
      d. Inlet protection in order to avoid system dry running  
   3. The VFD shall provide application control functions.  
      a. Stop and Go function in order to reduce consumption of the VFD in case the pump does not work  
      b. Pulse input for connection to flow meter feedback  
      c. Process control (PID) function in order to maintain a process at a given pressure or flow reference  
      d. Flow limitation function in order to allow limiting the consumption of water  
      e. Friction loss compensation function in order to compensate pressure losses in pipes due to friction  
      f. Pipe Fill function in order to manage a smooth control during pipe filling and to lessen the affects of water hammer  
      g. Sleep wake-up function in order to manage periods of the application when process demand is low and when it is not needed  
      h. Low demand function in order to define periods of the application when process demand is low in order to save energy
i. Jockey pump control function in order to start a jockey pump, during sleep period, to maintain emergency service pressure or demand, such as low water
j. Sensor management in order to define how VFD inputs will be used to manage the pressure sensor or flow sensor

4. The VFD shall provide application protection functions.
   a. High flow protection function in order to detect pipe burst or detect running outside normal working area
   b. Outlet pressure protection function in order to fix minimum and maximum pressure

5. The VFD shall provide pump curve input to help optimize pump performance.
   a. Input and storage of the pump characteristics including five (5) points of the pump curve.
   b. A best efficiency point (BEP) function in order to operate at maximum system efficiency and alarms to indicate deviation from BEP.

F. The VFD Supplier shall have Windows-based PC software for configuring and diagnosing the VFD. It shall be possible to set and modify parameters, control the VFD, read actual values, and make trend analysis using the software. The PC tools may be connected to the VFD by a wired or wireless connection.

G. The VFD shall display all faults in plain text and help screens shall be available to guide the user in troubleshooting. Codes are not acceptable.

H. The VFD shall provide a real time clock for time stamping detected errors.

I. The VFD shall display detected errors with QR codes to guide the user in the troubleshooting.

J. The VFD must provide LED lights to indicate its status such as Power On, Run, Fault condition, active communications.

K. The VFD must have the ability to dynamically display I/O status.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the VFD exterior and interior prior to installation. Report any damage and do not install any VFDs that are structurally, moisture, or mildew damaged.

B. Prior to locating the VFD at the planned installation site, ensure that the location is prepared for the installation and that the storage or operating condition requirements can be maintained. Verify that the installation space requirements are satisfied. Report any conditions that are detrimental to performance of the work. Proceed with installation only after detrimental conditions have been corrected.

C. Before, during, and after installation ensure that the VFD is protected from area construction activities and site contaminants.

3.2 INSTALLATION

A. Installation shall comply with manufacturer's instructions, drawings, and recommendations.
3.3 FIELD QUALITY CONTROL

A. Configuration and startup: Provide the services of a qualified factory-trained manufacturer’s representative to assist the installing contractor with the installation, configuration, and startup of each VFD. The manufacturer’s representative shall inspect the installation of each VFD prior to energizing and configure each VFD for operation under the specified conditions. The manufacturer’s representative shall conduct the initial startup and operation of each VFD. The manufacturer’s representative shall revisit the project site as often as necessary to ensure that all issues are corrected and that the installation and operation of the VFD are satisfactory.

B. Certification: The Contractor shall submit a written report certifying that each VFD has been installed, configured, and tested under load in accordance with the manufacturer’s recommendations. This report shall be signed by a factory-trained manufacturer’s representative and shall include a listing of all modifications and adjustments made on site to include any settings/parameters that are not identified as factory defaults in the equipment’s O&M documentation.

C. Specified products shall be tested as a system for conformance to specification requirements prior to scheduling the acceptance tests. The Contractor shall conduct performance verification tests in the presence of a Government representative, observing and documenting complete compliance of the system to the specifications. The Contractor shall submit a signed copy of the test results, certifying proper system operation before scheduling tests.

3.4 TRAINING

A. The services of a factory-trained instructor shall be provided for the purpose of training the Owner’s staff in the proper operation and maintenance of the VFDs. Training shall consist of not less than [1] session(s) with [4] hours of onsite classroom and hands-on instruction for a minimum of [4] attendees per session. The instructor shall provide sufficient time and detail in each session to cover the following as a minimum:

1. Theory of operation
2. Operation of VFDs furnished
3. Maintenance and configuration
4. Configurations of VFDs furnished
5. Troubleshooting and repair
6. Replacement of component level parts
PART 1 GENERAL

1.01. SCOPE OF WORK

A. Furnish, install and test the motor control center as shown on the Drawings and as specified herein.

1.02. REFERENCE STANDARDS

A. Motor control centers shall be designed, built and tested in accordance with NEMA Standard ICS-2 and Underwriters Laboratories (UL) Standard No. UL-845. Equipment shall conform to ANSI C19.3 test standards and the requirements of the National Electric Code (NEC).

B. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.03. QUALITY ASSURANCE

A. The motor control center shall be the product of a manufacturer who shall also be the manufacturer of all the circuit breakers, fused switches and motor starters included in the motor control center and who has produced the same type of equipment for a period of at least 15 consecutive years.

B. Motor control center[s] shall be designed, assembled and tested by the manufacturer of the motor control equipment included in the control center assembly.

C. All units and sections shall be UL labeled. Motor control centers containing service entrance equipment shall be UL labeled "Suitable For Use As Service Equipment."

1.04. SAFETY

1. Provide Energy Reducing Maintenance Mode Switch
2. Provide Tin Plated Copper Bus
3. Provide IR Inspection Windows
4. Provide Microprocessor Based Power Meter
5. Provide Permanent Electrical Safety Device (PESD) connected upstream of the main device. Graceport Safeside P-S10S21-M3RX-xxx or appropriate equal.

1.05. MANUFACTURERS

A. The general arrangement of the motor control center is shown on the Drawings. Motor control center shall be one of the following products or equal:

PART 2 PRODUCTS

2.01. CONSTRUCTION

A. Enclosure

1. Enclosure type shall as noted on the Drawings.

B. Structure

1. Motor control center shall consist of a series of metal enclosed, free-standing, dead front vertical sections bolted together to form double wall construction between sections. Individual vertical sections shall be nominally 90-in high, 20-in wide and 20-in deep unless otherwise shown on the Drawings. Bottom channel sills shall be mounted front and rear of the vertical sections extending the full width of each shipping split. Top of each section shall have removable plates with lifting angle. Make provisions for field installation of additional sections to each end and provide full depth cover plates (rodent barriers) at each end of the motor control center channel sills.

2. Provide continuous top and bottom horizontal wireways extending the full width of the line-up, isolated from the horizontal bus. Provide a 4-in wide, full height, vertical wireway in each section, equipped with a hinged door and cable supports. Vertical wireway shall be isolated from the bus and device compartments. Wireway openings shall have rolled edges or protective grommets.

3. Provide individual, flange formed, pan type door with concealed hinges and quarter turn latches for each device compartment and future space. Doors shall be removable. Door removal shall not be required to withdraw starter units or feeder tap devices.

4. Motor control center shall be designed for against-the-wall mounting. All wiring, bus joints and other mechanical parts requiring tightening or other maintenance shall be accessible from the front or top.

C. Unit Compartments

1. Provide individual compartments for each removable combination starter and feeder tap device unit. Each vertical section shall accommodate a maximum of six compartments. Steel barriers shall isolate the top, bottom and sides of each compartment from adjacent units and wireways. Removable units shall connect to the vertical bus in each section with tin plated, self-aligning, pressure type copper plug connectors. Size 5 and larger starter units may be wired directly to
the bus. Removable units shall be aligned in the structure on guide rails or shelves and secured with a cam latch mechanism or racking screw.

2. Provide individual, isolated compartments for fixed mounted devices such as circuit breakers, cable lugs, metering, relaying and control devices. Main and bus tie circuit breakers shall be wired directly to the main horizontal bus. All bus connections shall be fully rated.

3. Provide the following features:
   a. Provision to padlock removable units in a partially withdrawn TEST position, with the bus stabs disengaged.
   b. Provision to padlock unit disconnect handles in the OFF position with up to three padlocks.
   c. Mechanical interlock with bypass to prevent opening unit door with disconnect in the ON position, or moving disconnect to the ON position while the unit door is open.
   d. Mechanical split-type terminal blocks for disconnecting external control wiring.
   e. Auxiliary contact on unit disconnect to isolate control power when fed from an external source.
   f. Disconnect operating handles and control devices mounted on the removable units.
   g. Compartments containing motor starters shall have wiring diagrams and heater tables fastened to the compartment door. Compartments containing panelboards shall have circuit directories fastened to the compartment door. Diagrams, tables and directories shall consist of two ply laminated plastic, with black face and white core.

D. Bus Systems

1. Main horizontal bus: Tin plated copper, bolted joints, accessible from the front of the structure, fully rated throughout the lineup.

2. Vertical section bus: Tin plated copper, full height, totally insulated and isolated by glass polyester barriers with shutters to cover stab openings when units are withdrawn. Provide fishtape barriers to isolate bottom wireways from lower ends of vertical bus.

3. Vertical buses used for a tie circuit breaker or tie feeder lugs shall be rated for a continuous capacity equivalent to the main horizontal bus rating.

4. Horizontal ground bus: Provide a tin plated copper ground bus in each section equipped with lugs for termination of feeder and branch circuit ground conductors. Connect to ground bus in adjacent sections with splice plates.
E.  Wiring

1.  Wiring: Stranded copper, minimum size No. 14 AWG, with 600 Volt, 90 degree C, flame retardant, Type MTW thermoplastic insulation, NEMA Class II-S, Type B. Line side power wiring shall be sized for the full rating or frame size of the connected device.

2.  Identification: All wires shall be numbered with type written heat shrinkable wire markers at each termination point, color coding per NEMA standards and the NEC. Foreign voltage control wiring shall be yellow.

2.02.  COMPONENTS

A.  General

1.  The Drawings indicate the approximate horsepower and intended control scheme of the motor driven equipment. Provide the NEMA size starter, circuit breaker trip ratings, control power transformers and thermal overload heater element ratings matched to the motors and control equipment actually supplied, in compliance with the NEC and the manufacturers' heater selection tables. All variations necessary to accommodate the motors and controls as actually furnished shall be made without extra cost to the Owner.

B.  Circuit Breakers

1.  Power circuit breakers (400 Amp and larger): 100 percent equipment rated, 600 Volt, molded case circuit breakers with integral fully adjustable solid state trip device. Trip device shall be temperature insensitive and have the following characteristics and functions:

   a.  Independently adjustable long time pick-up and delay.

   b.  Independently adjustable short time pick-up and delay with I2t in and out switch.

   c.  Adjustable instantaneous.

   d.  Independently adjustable ground fault pick-up and delay.

   e.  Trip mode targets for over load, short circuit and ground fault.

   f.  Long time pick-up light.

2.  Circuit breakers (less than 400 Amps): Thermal-magnetic trip type, 600 Volt, 2 or 3 Pole as required, labeled in accordance with UL 489. Provide integral current limiting fuses as required to meet the specified equipment short circuit rating. Provide independently adjustable magnetic trips on 225 Amp frame breakers and larger.

C.  Branch Circuit Feeder Breakers (Non-motor loads)
1. Molded case circuit breakers: Thermal-magnetic trip type, 600 Volt, 2 or 3 Pole as required, labeled in accordance with UL 489. Circuit breakers shall be fully rated to meet the specified equipment short circuit rating. Provide independently adjustable magnetic trips on 225A frame breakers and larger.

D. Combination Starter Units

1. Combination starters shall include a motor circuit protector (MCP) in series with a motor controller and an overload protective device. The MCP shall have an adjustable magnetic trip range up to 1000 percent of rated continuous current and a trip test feature. MCP’s shall be labeled in accordance with UL489.

2. Motor starters: 3 Pole, 600 Volt, electrically operated, of the types shown on the Drawings. Provide NEMA sizes as required for the horsepowers shown on the Drawings. Minimum size shall be NEMA Size 1. Fractional size starters are not acceptable. IEC rated starters shall have continuous current ratings equal to or greater than the continuous current ratings listed in Table 2-321-1 of NEMA Standard Publication ICS 2. Starters shall have 120 Volt encapsulated operating coils; individual control power transformers with primary and secondary fuses and silver cadmium oxide renewable line contacts.

3. Multi-speed and reversing starters shall include two motor rated contactors mechanically and electrically interlocked so that only one device may be energized at any time.

4. Reduced voltage starters: Auto-transformer type with closed circuit transition. Auto-transformers shall be dry type with 50, 65 and 80 percent voltage taps and over-temperature protection. Timing relays shall be pneumatic, adjustable. Relay settings shall be approximately 75 percent of relay range.

5. Wye-delta starters shall be closed circuit transition for use with 6 or 12 lead motors.

6. Contactors: Electrically held, 120 VAC coil operator, suitable for tungsten, ballast, or resistive non-motor loads, with over current protection, control transformer and contact ratings and poles as shown on the Drawings.

7. Motor overload protection: Ambient compensated, adjustable, 3 Pole, thermal bi-metallic or melting alloy type, with push-to-test feature. Overload relays for submersible pump motors shall be ambient compensated, quick trip, Class 10. Overload relays shall be manually reset from outside the enclosure by means of an insulated pushbutton. Provide auxiliary alarm contacts where shown on the Drawings.

8. Auxiliary contacts: Form C, NEMA A600 rating, as required by the control schemes on the Drawings. Provide 1-normally open and 1-normally closed spare contacts on each starter. Additional auxiliary contacts shall be furnished as shown on the Drawings or as required by the control schematic and this Section.
9. Control power transformers: Two winding type, 120 VAC secondary, fused in accordance with the NEC. Provide extra capacity as required or where shown on the Drawings.

E. Instrumentation and Metering

1. Provide micro-processor based metering units where indicated on the Drawings. Meters shall display all digital values of power such as voltage, current, phases, power factor, kW demands, etc. Meters shall be manufactured by one of the following:
   a. Allen-Bradley - Bulletin 1403LM
   c. Square D Company - Power Logic series
   d. Siemens Energy & Automation - Model 4700 series
   e. Or equal

F. Pilot Devices

1. Control operators: Heavy duty, full size, oiltight, with NEMA A600 contact rating. Types and quantities as shown on the Drawings.

2. Indicator lights: Full size, oiltight, low voltage, with push-to-test feature. Colors and quantities as shown on the Drawings.

G. Miscellaneous Units

1. Bus connected surge protection: Provide “Control Guard” industrial grade suppression filter system as manufactured by Current Technologies, Inc.; Lightning Eliminators and Consultants, Inc., or equal. The unit shall be designed to occupy a NEMA size 1 MCC compartment, and shall have the following ratings and features:
   a. 200 KA single pulse surge capacity per phase.
   b. UL 1449 high performance surge suppression system
   c. UL 1283 high frequency extended range power filter
   d. UL 845 listed
   e. Minimum No. 6 AWG copper conductor in the surge suppression path
   f. Maximum Continuous Operating Voltage (MCOV) 115 percent of nominal
   g. Status and disturbance indicators
h. Integral fused disconnect switch

2. Power factor correction capacitors: 600 Volt, 3 Phase, with current limiting fuses, discharge resistor, sized to correct motor power factor to approximately 0.95.

3. General purpose transformers: Open, dry-type, with primary and secondary overcurrent protection in accordance with the NEC, size and voltage ratings as shown on the Drawings. Refer to Section 16191 for additional requirements.

4. Lighting and Distribution Panelboards: Main lug only, factory wired to transformer, bolt-on branch circuit breakers, size and voltage rating as shown on the Drawings. Refer to Section 16470 for additional requirements.

2.03. SURFACE PREPARATION AND SHOP COATINGS

A. All non-current carrying metal parts of the control center assembly shall be cleaned of all weld spatter and other foreign material and given a heat cured, phosphatized chemical pre-treatment to inhibit rust.

B. Indoor equipment shall be finish painted with one coat of manufacturers’ standard electrocoated, heat cured enamel. Color shall be ANSI 49 or 61 light gray.

2.04. SHOP TESTING

A. Perform manufacturers’ standard production testing and inspection in accordance with NEMA and ANSI standards. Submit certified copies of the test results and reports.

PART 3 EXECUTION

3.01. INSTALLATION

A. Motor control center floor sill shall be bolted directly to the finished floor or equipment pad. Structure shall be leveled and plumb. Provide hardware and shims for installation.

B. Field installed interior wiring shall be neatly grouped by circuit and bound by plastic tie wraps. Circuit groups shall be supported so that circuit terminations are not stressed.

C. In general, all conduit entering or leaving a motor control center shall be stubbed up into the bottom horizontal wireway directly below the vertical section in which the conductors are to be terminated, or shall enter the motor control center from the top. Conduits shall not enter the motor control center from the side unless approved in writing by the Engineer.

D. Housekeeping pads shall be included for the motor control centers as detailed on the Drawings with the exception of motor control centers which are to be installed adjacent to an existing unit. Housekeeping pads for these (if used) should match the existing installation.

E. Install the equipment in accordance with the manufacturer’s instructions.
F. Remove temporary lifting angles, lugs and shipping braces. Touch-up damaged paint finishes.

G. Make wiring interconnections between shipping splits.

H. Install bus splice plates and torque connections.

I. No operator devices shall be located over 6-ft-6-in above the finished floor. Circuit breaker operation handles more than 6-ft-6-in above the finished floor shall have operating arm extensions.

3.02. FIELD TESTING

A. Make the following minimum tests and checks before the manufacturer's representative is called in for testing and adjustment.

1. Megger incoming line terminals and buses, phase-to-phase and phase-to-ground after disconnecting devices sensitive to megger voltage.

2. Remove current transformer shunts after completing secondary circuit. Check polarity and continuity of metering and relaying circuits.

3. Check mechanical interlocks for proper operation.

4. Test ground connections for continuity and resistance.

5. Adjust unit compartment doors.

6. Check control circuit interlocking and continuity with starters in the TEST position. Provide external source of control power for this test.

7. Adjust motor circuit protectors and voltage trip devices to their correct settings.

8. Install overload heaters or adjust relays for actual motor nameplate currents. If capacitors are installed between starter and motor, use overload relay heaters based on measured motor current.

3.03. CLEANING

A. Remove all rubbish and debris from inside and around the control center. Remove dirt, dust, or concrete spatter from the interior and exterior of the equipment using brushes, vacuum cleaner, or clean, lint-free rags. Do not use compressed air.

END OF SECTION
PART 1 - GENERAL

1.1 DESCRIPTION

A. This specification describes a complete adjustable speed AC drive (VFD) WITH INTERNAL BYPASS used to control the speed of NEMA design B induction motors used in areas where low harmonic content is desired or mandated.

B. The manufacturer shall supply the VFD and all necessary controls as herein specified.

C. The VFD shall be manufactured by a company with at least ten (10) years’ experience in the production of this type of equipment.

<table>
<thead>
<tr>
<th>Performance Data</th>
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<tr>
<td>Amps</td>
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<tr>
<td>61 (field verify)</td>
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</table>

1.2 QUALITY ASSURANCE

A. The VFD manufacturing facility shall be ISO 9001 and ISO 14001 certified.

B. All printed circuit boards shall be completely tested before being assembled into the complete VFD. The VFD shall be subjected to a functional test and load test. The load test shall be at full rated load, or cycled load.

C. The VFD manufacturer shall have an analysis laboratory to evaluate the failure of any component.

1.3 QUALIFICATIONS

A. The VFD shall meet the following specifications
   1. UL 508A, 508C, or UL-61800-5 – Underwriter’s Laboratory.
   2. CAN/CSA-C22 No. 14-M91 – Canadian Standards Association. The VFD shall be C-UL or CSA Listed and carry the appropriate mark.
4. The VFD shall comply with the following European Union’s CE directives. The VFD shall carry the CE mark.
   a. EMC Low Voltage Directive 73/23 EEC
   b. EMC Directive 89/336 EEC
   c. Machinery Directive 98/37 EC

B. Acceptable manufacturers
   1. Schneider Electric Altivar 680 Low Harmonic VFD utilizing 3-level Type Active Rectification with integrated power modules.
   2. VFDs that are manufactured by a third party and “brand labeled” shall not be acceptable.
   3. VFD power structures that are manufactured by a third party and “brand labeled” shall not be acceptable.
   4. The low harmonic VFD must use 3-level active rectification to be considered an “approved equal.”
   5. AFE Units without 3-level PWM technology (if approved) will require motor dv/dt output filters and common mode noise filters.
   6. **VFD shall be provided with internal bypass.**

1.4 SUBMITTALS

A. The Submittals shall include the following information:
   1. Outline dimensions and weight
   2. Customer connection and power wiring diagrams
   3. Complete technical product description, including a complete list of options provided
   4. Harmonic test data for both utility and generator power sources demonstrating harmonic current distortion up to the 30th harmonic at VFD input terminals
   5. Compliance to IEEE 519 – Harmonic analysis for the particular jobsite including total current distortion. In case an alternative low harmonic solution is offered, the VFD manufacturer shall provide calculations, specific to the jobsite, showing that the total harmonic current distortion (TDD) at the Point of Common Coupling (PCC) is at or below THDi limits as recommended by IEEE 519- June 2014.

PART 2 - DESIGN

2.1 DESCRIPTION

A. The VFD shall be a solid-state, AC-to-AC inverter-controlled device using the latest insulated gate bipolar transistor (IGBT) technology.

B. The VFD shall be a 3-level Active Front End (AFE) AC drive that is designed to comply with standard IEEE 519-2014 when installed in a system that is already in compliance with the standard. A 3-level design shall be used to provide a low harmonic current load to the power system and to avoid introducing additional common mode noise to the motor. Passive harmonic filters shall be acceptable for motors less then 150hp in size provided the TDD is shown to be less than limits established by IEE 519-2014. The 2-level type design shall not be acceptable due to the additional common mode noise output from the VFD to the motor.
2.2 HARMONICS

A. The AFE low harmonic construction of the VFD shall not contribute any significant harmonics at the input terminals of the VFD shall contribute no more than 5% THDi at the input terminals.

B. All harmonic management devices must be internal to the VFD enclosure and supplied as a complete solution.

C. The VFD shall have an active line supply unit which controls the waveform of the input current and reduces the low order harmonic current drawn from the power line. Line currents and voltages shall be nearly sinusoidal. IGBTs shall be used in the rectified and inverter circuits.

D. Each input phase of the VFD shall incorporate a symmetrical inductor-capacitor-inductor (LCL) filter high frequency arranged in a T-configuration. The inductors are to be series power components that carry the full current of the VFD.

E. The input current to the VFD shall have a total harmonic content less than 5% of full rated capability at the input terminals of the VFD on a power system sized according to IEEE 519-2014, at line voltage unbalance up to 2%, and under all motor load conditions.

F. The VFD shall operate at a fundamental power factor .98 or higher on the supply side when operating above 20% of rated full load current.

G. The VFD's design shall not compensate for existing harmonic content in the distribution system.

2.3 Ratings

A. The VFD shall be rated to operate from 3-phase power, 380 Vac to 480 Vac +10/-10%. The overvoltage trip level shall be a minimum of 30% over nominal, and the undervoltage trip level shall be a minimum of 35% under the nominal voltage.

B. The VFD shall be rated to operate at the following environmental operating conditions. Ambient temperature: 0 to 40 °C continuous. VFDs that can operate at 40 °C intermittently (during a 24-hour period) are not acceptable and must be oversized Altitude: 0 to 3300 feet above sea level without derating, less than 95% humidity, non-condensing. The VFD shall have the capability to operate up to 50 °C with derating.

C. The low harmonic ATV680 VFD shall be offered from 150 through 900 hp normal duty, and 125 through 700 hp heavy duty, in similar construction and operation, using the same 3-level topology. For motor power ratings less than 150 hp, the use of an Altivar Process ATV630 VFD with passive harmonic filter is required.

D. The VFD shall be rated to operate from input power of 48 to 63 Hz.

E. Output voltage and current ratings shall match the adjustable frequency operating requirements of standard NEMA design A or NEMA design B motors.

F. The normal duty overload current capacity shall be 110% of rated current for one (1) minute out of ten (10) minutes.

G. The heavy-duty overload current capacity shall be 150% of rated current for one (1) minute out of ten (10) minutes.
2.4 Construction

A. The VFD manufacturer shall provide a complete package, ready-to-install solution. Third party entities that use VFD controllers from others in their package designs are not acceptable.

B. The most efficient IGBT power technology shall be used. This technology shall be used for all power and voltage ranges offered by the manufacturer.

C. The VFD shall offer microprocessor based control logic that is isolated from power circuitry.

D. The VFD shall use the same main control board for all ratings.

E. Control interfaces shall remain consistent for all power ratings.

F. The VFD shall use active input modules that employ 3-level type active rectification.

G. The VFD shall be offered in UL Type 1 or UL Type 12.

H. VFDs at all power rating shall be of free-standing construction and shall include the following standard features both passive filter solutions and Active Front End systems.
   1. A circuit breaker with a combination AIC Rating of 100,000 amperes.
   2. Modular power modules in the cabinet for quick removal and replacement of individual modules. The modular construction also allows for adaptation of the enclosure unit to individual requirements. The modularity and accessibility of the drive components allow for servicing without relocation of the drive enclosure.
   3. To ensure fast and easy handling, all VFD shall have a modular power modules and heavy power components such as Inverter IGBT Line Filtering and third level bi-directional IGBT.

I. All options as shown on drawings and specified in Section XXX shall be furnished and mounted by the VFD manufacturer. All optional features shall carry all of the necessary certifications as described in Section 1.03. Field installed kits shall not affect the VFD’s certification.

2.5 Operator Interface

A. A detachable UL Type 12 / IP65 rated bi-color backlit graphical user interface terminal with keypad and capacitive wheel shall be provided for monitoring, annunciation, and configuration. The graphical display shall change to a red backlit color when an alarm occurs. The mechanical mounting for the user interface on the cabinet shall be done with a 22 mm hole.

B. A “Simply Start” menu for fast and easy commissioning shall be provided. Parameter setting shall be easily accessible and user friendly with plain text messaging and actual setting range.

C. The keypad shall be capable of providing password protection.

D. The user interface shall be capable of saving and downloading configurations of the VFDs, as well as importing them to other VFDs.

E. The user interface shall offer a mini USB port for mass storage or PC device connection.
F. The VFD shall have self-diagnostic capabilities to display alarms, errors, and warnings as they occur and shall be able to store into memory the last 15 messages, at minimum. These shall be accessible by PC maintenance tools or by web server, with flash record for data logging.

G. The VFD shall have a separate dedicated RS232 Modbus serial port for the keypad and shall allow for simultaneous use of a remote mounted keypad with RS485 serial communications network.

H. The displayed messages shall be in plain text.

I. The display of the control unit shall have the following features:

1. During normal operation, one (1) line of the control panel shall display the speed reference, run/stop status, forward/reverse status, and local/remote status. The remaining three (3) lines of the display shall be programmable to display the values of any three (3) operating parameters. The selection shall include at least the following values:
   a. Speed/torque in percent (%), RPM, or user-scaled units
   b. Output frequency, voltage, current, and torque
   c. Input voltage, power, and kilowatt hours
   d. Heatsink temperature and DC bus voltage
   e. Status of discrete inputs and outputs
   f. Values of analog input and output signals
   g. Values of PID controller reference, feedback, and error signals

2.6 Protective Features

A. The VFD shall be UL 508 or UL61800-5-1 Listed for use on distribution systems.

B. The VFD shall have coordinated short-circuit rating designed to UL 508C or UL 61800-5-1 and NEMA ICS 7.1 short-circuit rating:[100] kAIC.

C. Voltage sag immunity per SEMI F47.

D. Upon power-up, the VFD shall automatically test for valid operation of memory, option module, loss of analog reference input, loss of communication, AC-to-DC power supply, control power, and the pre-charge circuit.

E. The VFD shall be protected against short circuits between output phases and ground and the logic and analog outputs.

F. The VFD shall have a selectable ride through function that will allow the logic to maintain control for a minimum of one (1) second without tripping.

G. The deceleration mode of the VFD shall be programmable for normal and trip conditions. The stop modes shall include freewheel stop and fast stop.

H. Upon loss of the analog process follower reference signal, the VFD shall trip and/or operate at a user-defined speed set by a software programmed speed setting or last speed.

I. The VFD shall integrate a protection against IGBT and heatsink overtemperature.

J. The VFD shall have solid-state thermal protection that is UL Listed and meets UL 508C / UL 508A as a Class 10 overload protection and meets IEC 947.
K. The VFD shall have a motor thermal memory retention function per UL requirements.

L. The VFD shall be able to protect the motor when temperature probes are connected.

M. The VFD shall be able to limit the motor surge limitation to twice the DC bus voltage. This must be accomplished by use of internal software. The VFD shall limit the motor surge limitation to value of not more than twice the DC bus voltage.

N. The VFD shall provide the following IGBT protection circuits.
   1. IGBT overcurrent protection
   2. IGBT check up sequence
   3. IGBT check up sequence before PWM enable sequence
   4. IGBT overheat protection

O. The VFD shall provide VFD current protection.
   a. Phase short circuit protection
   b. Ground protection
   c. Overcurrent protection

P. The VFD shall provide VFD voltage error protection.
   a. Mains overvoltage protection
   b. Mains undervoltage protection
   c. DC Bus overvoltage protection
   d. DC Bus pre-charge protection

Q. The VFD shall provide VFD Thermal protection.
   a. VFD overtemperature protection
   b. Fan management
   c. Switching frequency management

R. The VFD shall provide internal error detection.

S. The VFD shall provide motor protection functions
   a. Motor output phase detection
   b. Motor surge voltage
   c. Motor overload detection
   d. Motor stall protection

T. The VFD shall provide application protection functions
   a. Catch on fly function
   b. Mains input phase lost protection
   c. Motor overspeed input protection
   d. Current limitation
   e. Power limitation
   f. Reverse inhibition
   g. Underload protection
   h. Overload protection
   i. External error management
   j. Loss of follower signal
   k. Thermal sensor management
   l. PID feedback
   m. Customer defined input
2.7 Control Interface:

A. The VFD shall interface with automation systems to monitor, control, display, and record data for use in processing reports. VFD settings shall be retained in the VFD's nonvolatile memory.

B. The speed command reference shall be selectable from the following sources:
   1. I/O terminals
   2. Communication network
   3. Web server
   4. Remote graphic display terminal

C. A minimum of the following standard inputs/outputs shall be provided to interface with control systems and instrumentation:
   1. Analog inputs: [3] programmable 0(4)-20 mA or 0-10 Vdc
      a. Two (2) analog inputs shall also be programmable for temperature sensors (PTC, PT100, PT1000, KTY84)
   2. Analog outputs: Two (2) programmable 0(4)-20 mA or 0-10 Vdc
   3. Discrete inputs: [6] programmable isolated logic inputs as either sink or source
      a. Two (2) discrete inputs shall also be programmable as 0-30 kHz pulse inputs
      b. Two (2) discrete inputs shall be dedicated to the Safe Torque Off safety function in accordance with IEC/EN 61508-1 SIL3
      a. One (1) discrete output shall be dedicated to product watchdog logic

D. Programmable analog inputs shall be able to be assigned the following parameters:
   1. Speed reference
   2. Summing reference
   3. Subtracting reference
   4. Multiplying reference
   5. Torque reference
   6. Torque limitation
   7. PID feedback
   9. PID speed reference
   10. Forced local reference

E. Programmable analog outputs shall be able to be assigned the following parameters:
   1. Motor current
   2. Motor frequency
   3. Motor torque (signed or unsigned)
   4. Motor power
   5. Motor voltage
   6. Output frequency (signed or unsigned)
F. Programmable discrete inputs shall be able to be assigned the following parameters:
   1. Run

G. Programmable discrete outputs shall be able to be assigned the following parameters:
   1. Ready
   2. Drive running
   3. Frequency reference attained

H. Safety Inputs
   1. The VFD shall provide two (2) inputs dedicated to the Safe Torque Off (STO) safety function, which prohibits unintended equipment operation, in accordance with IEC/EN 61508-1 SIL3.
   2. The VFD shall be compliant with EN13849 (PL e).
   3. The VFD shall be compliant with “Safety of Machinery,” EN 954-1.
   4. The VFD manufacturer shall provide the certified schematics and the list of devices in order to comply with IEC/EN 60204-1 stopping category 0 and 1.
   5. The VFD shall integrate the safety contacts in compliance with EN-81 13.2.2.3.

2.8 Communications

A. The VFD shall provide at minimum one (1) Modbus and one (1) Ethernet Modbus TCP communication port.
   1. Ethernet IP or Modbus TCP, RJ45 dual port for daisy chain

B. VFD Ethernet ports shall be IPv6 compliant, allow for web server access, and provide network management via Simple Network Management Protocol, and clock synchronization.

C. The VFD shall provide an embedded web server for enhanced diagnostic, configuration, parameter access, and energy management. It shall be possible to create a user-defined custom dashboard for viewing VFD and process status through tables, charts, and graphical views. It shall be possible to export data in standard table format using the web server, for information about energy consumption as well as error and warning history.

D. The VFD shall be compliant with the Cyber Security Management ISA Secure / Achilles.

E. The VFD shall provide integration connectivity via:
   1. DHCP protocol for Fast Device Replacement
   2. DTM library in compliance with standard FDT technology

2.9 Control Functions and Configurations

A. The VFD shall be capable of accepting independent command and speed reference signals from:
   1. Terminals
   2. Modbus port
3. Ethernet port
4. Communication option card
5. Keypad display.

B. The VFD shall provide a speed set-point function capable of:
   1. Maximum output frequency function
   2. Low and high speed scaling and limitation function
   3. Jump frequency

C. The VFD shall provide a Stop function capable of:
   1. Deceleration ramp on power loss

D. The VFD shall have an acceleration/deceleration, time-adjustable ramp function capable of:
   1. Ramp type: linear ramp, S shape ramp, with U or customized profile
   2. Ramp deceleration adaptation
   3. Ramp switching

E. Application programming dedicated to pumps
   1. The VFD shall provide pump control and monitoring functions
      a. Centrifugal pump characteristics and configurations
      b. Pump monitoring function in order to define the data relevant for the pump (for example, acceleration, low speed, and high speed)
      c. Application units function in order to define the units used in applications
      d. Pump cyclic start protection in order to protect the pump against too many restarts in a dedicated time period
      e. Multi-pump functions
   2. The VFD shall provide pump protection functions.
      a. Anti-jam function in order to remove automatically clogging substances from the pump impellers
      b. Pipe cleaning function in order to start the pump regularly to avoid sedimentation in pump impeller
      c. Cavitation pump protection
      d. Inlet protection in order to avoid system dry running
   3. The VFD shall provide application control functions.
      a. Stop and Go function in order to reduce consumption of the VFD in case the pump does not work
      b. Pulse input for connection to flow meter feedback
      c. Process control (PID) function in order to maintain a process at a given pressure or flow reference
      d. Flow limitation function in order to allow limiting the consumption of water
      e. Friction loss compensation function in order to compensate pressure losses in pipes due to friction
      f. Pipe Fill function in order to manage a smooth control during pipe filling and to lessen the affects of water hammer
      g. Sleep wake-up function in order to manage periods of the application when process demand is low and when it is not needed
      h. Low demand function in order to define periods of the application when process demand is low in order to save energy
i. Jockey pump control function in order to start a jockey pump, during sleep period, to maintain emergency service pressure or demand, such as low water
j. Sensor management in order to define how VFD inputs will be used to manage the pressure sensor or flow sensor

4. The VFD shall provide application protection functions.
   a. High flow protection function in order to detect pipe burst or detect running outside normal working area
   b. Outlet pressure protection function in order to fix minimum and maximum pressure

5. The VFD shall provide pump curve input to help optimize pump performance.
   a. Input and storage of the pump characteristics including five (5) points of the pump curve.
   b. A best efficiency point (BEP) function in order to operate at maximum system efficiency and alarms to indicate deviation from BEP.

F. The VFD Supplier shall have Windows-based PC software for configuring and diagnosing the VFD. It shall be possible to set and modify parameters, control the VFD, read actual values, and make trend analysis using the software. The PC tools may be connected to the VFD by a wired or wireless connection.

G. The VFD shall display all faults in plain text and help screens shall be available to guide the user in troubleshooting. Codes are not acceptable.

H. The VFD shall provide a real time clock for time stamping detected errors.

I. The VFD shall display detected errors with QR codes to guide the user in the troubleshooting.

J. The VFD must provide LED lights to indicate its status such as Power On, Run, Fault condition, active communications.

K. The VFD must have the ability to dynamically display I/O status.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the VFD exterior and interior prior to installation. Report any damage and do not install any VFDs that are structurally, moisture, or mildew damaged.

B. Prior to locating the VFD at the planned installation site, ensure that the location is prepared for the installation and that the storage or operating condition requirements can be maintained. Verify that the installation space requirements are satisfied. Report any conditions that are detrimental to performance of the work. Proceed with installation only after detrimental conditions have been corrected.

C. Before, during, and after installation ensure that the VFD is protected from area construction activities and site contaminants.

3.2 INSTALLATION

A. Installation shall comply with manufacturer's instructions, drawings, and recommendations.
3.3 FIELD QUALITY CONTROL

A. Configuration and startup: Provide the services of a qualified factory-trained manufacturer's representative to assist the installing contractor with the installation, configuration, and startup of each VFD. The manufacturer's representative shall inspect the installation of each VFD prior to energizing and configure each VFD for operation under the specified conditions. The manufacturer's representative shall conduct the initial startup and operation of each VFD. The manufacturer's representative shall revisit the project site as often as necessary to ensure that all issues are corrected and that the installation and operation of the VFD are satisfactory.

B. Certification: The Contractor shall submit a written report certifying that each VFD has been installed, configured, and tested under load in accordance with the manufacturer's recommendations. This report shall be signed by a factory-trained manufacturer's representative and shall include a listing of all modifications and adjustments made on site to include any settings/parameters that are not identified as factory defaults in the equipment's O&M documentation.

C. Specified products shall be tested as a system for conformance to specification requirements prior to scheduling the acceptance tests. The Contractor shall conduct performance verification tests in the presence of a Government representative, observing and documenting complete compliance of the system to the specifications. The Contractor shall submit a signed copy of the test results, certifying proper system operation before scheduling tests.

3.4 TRAINING

A. The services of a factory-trained instructor shall be provided for the purpose of training the Owner's staff in the proper operation and maintenance of the VFDs. Training shall consist of not less than 1 session(s) with 4 hours of onsite classroom and hands-on instruction for a minimum of 4 attendees per session. The instructor shall provide sufficient time and detail in each session to cover the following as a minimum:

1. Theory of operation
2. Operation of VFDs furnished
3. Maintenance and configuration
4. Configurations of VFDs furnished
5. Troubleshooting and repair
6. Replacement of component level parts
203.998 Mobilization Bid Item – A mobilization bid item is included to help cover initial costs of bonds, insurance, permits, submittal preparation and other incidental costs.

203.998.1 Payment shall be made for a Mobilization Bid Item which is intended to cover the costs of bonds, insurance, permits, submittal preparation and other incidental costs. Payment of the Mobilization Bid Item may be requested in full on the first payment application. The Mobilization Bid Item shall not exceed five percent (5%) of the sum of all Base Bid Items excluding the Mobilization Bid Item. Add Alternate Items are not part of the Base Bid Items.

END OF SECTION
Mechanical, Electrical, Plumbing, and Unforeseen Circumstances Allowance –

$100,000.00 Lump Sum Allowance for various mechanical, electrical, plumbing, or unforeseen circumstances work not shown on the Construction Drawings or specified in the Contract Documents.

203.999.1 The allowance shall be used for cost of materials, labor, installation, and overhead and profit for additional MEP/Unforeseen Circumstances work that is not shown on the Construction Drawings or specified in the Contract Documents.

203.999.2 The allowance shall be used only at the discretion of the City of Tulsa. Any allowance balance remaining at the completion of the contract will be credited back to the City of Tulsa on the final Application for Payment submitted by the contractor.

203.999.3 The contractor shall provide to the City of Tulsa representative a written request for the use of any of the allowance with a schedule of values and all associated backup information.

203.999.4 The contractor shall proceed with work included in the allowance only after receiving a written order from the City of Tulsa representative authorizing such work. Proceeding with work expected to be covered in the allowance without a written order from the City of Tulsa representative will be at the contractor’s risk. Contractor may not be paid for unapproved work/materials at the discretion of the City of Tulsa representative.

203.999.5 Any additional costs for bonds and insurance shall not be included in any MEP allowance because this cost is already included in the contract.

END OF SECTION
ANCILLARY EQUIPMENT & WORK

The cost of items in this Section and other Sections of these specifications shall be equitably included in the appropriate Bid items.

204.1 Prior to disposal of any material or equipment that is City of Tulsa property and removed as part of the contract work, Contractor shall contact the appropriate WWTP Plant Superintendent and explicitly offer to the Authority first right to claim and retain such materials or equipment as City of Tulsa property. Contractor shall be responsible for the disposal of all such equipment and materials not claimed by the Authority. Items identified for salvage shall be removed carefully, protected, palletized and delivered to the Northside or Southside Maintenance Department. A copy of the Contractor's transmittal shall be provided to the Engineer after delivery.

204.2 Contractor shall field verify all elevations and dimensions of existing piping, valves, and equipment to be demolished. Contractor work shall be based on field measurements and shall include field adjustments and additions for the proper installation of equipment. The contractor shall take note of all objects in the vicinity of equipment being installed to ensure that there are no issues with interference. It is the responsibility of the contractor to make modifications necessary to adjacent objects such as pipe supports and similar to install the new equipment unless such objects are not reasonably visible during the site visit. It is the responsibility of the contractor to review all field conditions and take necessary field measurements prior to ordering equipment. The City of Tulsa will make available the information it has pertaining to the existing equipment.

204.3 General Equipment Requirements:

204.3.1 Approved Equal Equipment: The manufacturers and models specified in the equipment specifications are considered pre-approved. The winning contractor may, at their discretion, submit for approval equipment that has not been approved prior to the bid opening. When doing this, the contractor should be aware that the submitted equipment must not only meet the performance requirements stated in the equipment specifications, but it also must meet or exceed the manufacturing, material, and quality specifications of the pre-approved equipment even though those specifications are not expressly listed in the section. The Engineer will review any non pre-approved equipment through the submittal process and compare it with the pre-approved equipment to determine that the equipment is or is not equal. Contractor should be
prepared to supply technical data, material information, standards conformance information, and other related information as requested by the Engineer. If the requested information is not supplied, the equipment will be deemed to be not equal. Approval of non pre-approved equipment will be at the sole discretion of the Engineer.

204.3.2 Equipment Demolition: All equipment shall be demolished in accordance with each bid item section. No existing equipment is to be abandoned in place unless specifically noted otherwise. All equipment being removed during demolition shall either be set aside for determination of surplus value or disposed of by the contractor per each bid item specification. If after removing the old equipment and installing the new equipment there are unused items still in place, it shall be the responsibility of the contractor to remove these items in a manner that will not affect adjacent equipment or systems. All removed electrical and fluid components shall be properly capped off at the point of removal. Removal shall be performed in a manner that will allow re-installation/replacement of the removed items at a later date if necessary.

204.3.3 Gauges: Each pump shall be provided with a combination pressure/vacuum gauge in the suction piping and a pressure gauge in the discharge piping. Gauges shall conform to ANSI/ASME B40.1 and shall be indicating dial type, with C-type phosphor bronze Bourdon tube and stainless steel rotary geared movement, or direct drive type with stainless steel helical-wound capillary tube pressure sensing element. The gauge shall have a phenolic open front turret case, and adjustable pointer, a stainless steel or phenolic ring, and an acrylic or shatterproof glass window. The dial shall be 4 ½ inches in diameter, with white background and black markings. Pointer travel shall span not less than 200 degrees or more than 270 degrees. All gauges shall be Accuracy Grade A or better. Pressure gauges shall read in pounds per square inch. Compound gauges shall read in inches of mercury vacuum and pounds per square inch. The range of each gauge shall be per pump manufacturer’s recommendation.

All gauges shall be installed with a diaphragm seal, brass flushing port and brass isolation valve of appropriate size.

204.3.4 Mechanical Seals and Seal Water:
204.3.4.1 All pumps shall be equipped with cartridge mounted double mechanical seals recommended by the pump manufacturer and compatible with Pump Seal Water Support Systems (PSWSS) installed at each pump. Refer to Construction Drawings and pump specifications for additional requirements.

204.3.4.2 The new seal water conditioning station (SWCS) and PSWSS may contain components that were not originally part of an existing seal water system. It is the responsibility of the contractor to supply and install all necessary electrical components including wiring, conduit, connectors, contactors, etc… for a complete installation of the new seal water system. It may also be necessary to integrate the new seal water system components into the existing equipment control system. The contractor shall be responsible for all labor and materials required to integrate new components into the existing control system. All electrical work on the seal water station shall conform to the General Electrical Requirements herein. Contractor shall demolish and remove all existing seal water components not reused in construction.

204.3.4.3 Seal water piping and accessories shall not utilize rigid PVC piping. Seal water lines connected directly to the mechanical seals shall be PEX. All other piping in the seal water station shall be of a non-corrosive metal material such as stainless steel, or painted copper. Valves and other components shall be bronze unless otherwise required.

204.3.4.4 Some existing pumps do not have mechanical seals. Contractor shall determine from field investigations the location of seal water for those pumps. It is the responsibility of the contractor to supply and install all seal water piping, electrical work and materials, and control work and materials required to add a seal water station where one was not used for existing equipment. Locations are to be approved by the engineer.
204.3.4.5 If a new pump is installed that does not require seal water and there are existing seal water lines at the pump location, it is the responsibility of the contractor to remove existing water lines. Lines shall be removed as far up stream as possible to a point that will not interfere with water supply to other equipment. No existing lines shall be abandoned in place.

204.3.5 **Valves:**

204.3.5.1 All valve parts and surfaces shall be of corrosion resistant materials or have a factory applied epoxy coating sufficient to prevent corrosion in a wastewater environment. See painting/coating section for coating thickness requirements.

204.3.5.2 Plug Valves and Check Valves: Plug valves and check valves shall be of the same size, style and construction as the units being replaced. It is the responsibility of the contractor to review the existing valves and provide correct similar units. Acceptable manufacturers are Pratt, DeZurik, Clow, Val-Matic, or an approved equal.

204.3.5.3 Butterfly Valves: Butterfly valves shall be of the same size, style, and construction as the units being replaced. It is the responsibility of the contractor to review the existing valves and provide correct similar units. Acceptable manufactures are DeZurik, Clow, Val-Matic, or an approved equal.

204.3.5.4 Gate Valves: Gate valves shall be of the same size, style and construction as the units being replaced. It is the responsibility of the contractor to review the existing valves and provide correct similar units. Acceptable manufacturers are Wey, DeZurik, or approved equal.

204.3.5.5 Plug and butterfly valves supplied with hand wheel operators that are installed more than 6’-0” above floor level shall be supplied with chain wheels and chains to allow for valve operation from the floor.

204.3.5.6 Valves and operators shall be selected by the contractor such that when installed in close proximity to one another
the operators will be a sufficient distance apart to allow for uninhibited use by personnel.

204.3.6 **Equipment Tagging:** New equipment shall be tagged, according to the requirements listed below, with a permanent and visible tag showing the new equipment number using the City of Tulsa Equipment ID numbering system. All tags should be visible to anyone without the need to remove covers or otherwise “hunt” for the tag. See individual equipment sections for Equipment ID numbers for each item. Tags shall conform to the following specifications.

204.3.6.1 Requirements:

- Any equipment valued over $1,000
- All Valves greater than 6”
- All relief and motorized valves that are smaller than 6”
- Any equipment that requires preventive maintenance
- Any equipment that is critical to the process of the plant
- Any equipment that is considered a Safety item
- Emergency Eyewash/Shower
- Fire Extinguishers
- All Ladders
- Hoists
- Detectors
- Overhead Doors
- Fire Alarms/Sprinklers
- Emergency Lights

204.3.6.2 Equipment ID tag numbering shall meet the following requirements:

**PRODUCTS**

**Equipment ID Number Plates**

All equipment tagged on the drawings, except for buried submerged equipment shall be provided with an Equipment ID Number Plate bearing
the equipment tag number identified on the drawings. Equipment ID Number Plates shall be rectangular 3.5"x .75" and 1/16" thick laminated blue phenolic plastic engraving stock that is U/V stable. Lettering shall be 1 line of text, centered, and white capitalized block letters .25" high and engraved to a depth of 0.08mm.

Equipment ID Number Plates must follow the Equipment ID numbering scheme. Each equipment or systems should also include an additional tag noting the general name of the equipment or system adjacent to the equipment ID numbering tag (ie “Final Clarifier #3”, VFD for Pump #2, etc).

Equipment ID Number Plates shall be attached with permanent adhesive.

Additional Number Plates shall be provided for ancillary devices associated with each piece of new tagged equipment. Additional tags shall be provided for all electrical disconnects, variable frequency drives and Motor Control Centers whether new or existing.

**VALVE AND GATE EQUIPMENT ID NUMBER PLATES**

**Equipment ID Number Plates**

All valves and gates, except buried or submerged valves, that have been assigned an Equipment ID number on the Drawings or in the valve or gate schedule, shall be provided with a permanent number plate.

Equipment ID Number Plates shall be round 1.5" and 1/16" thick laminated blue phenolic plastic engraving stock that is U/V stable. Lettering shall be in 3 sections, centered, and white capitalized block letters 3/16" high and engraved to a depth of 0.08mm.

Example: 1st line XXXX-

2nd line XXXX-

3rd line XXXXX

Equipment ID Number Plates must follow the Equipment ID numbering Scheme.

Equipment ID Number Plates shall be attached with permanent stainless cable ties or stainless fasteners.
204.3.7 **Equipment Coatings:** All equipment shall be supplied with a factory applied coating sufficient to withstand a wastewater environment. Factory applied coating shall be in accordance with the painting/coating section.

204.3.8 **Equipment Installation:** All anchor bolt connections shall include the use of a washer, lock washer, and nut (without nylon or similar insert).

204.3.8.1 Installation of all equipment and related items shall be performed as directed in the manufacturer’s installation instructions.

204.3.8.2 No cutting, drilling or welding of new equipment or part thereof as delivered from the manufacturer for the purpose of adapting or modifying said unit to facilitate its installation will be permitted without written prior approval by the authority.

204.3.8.3 The Contractor shall be responsible for any and all concrete modifications that may be required to install the new equipment. This shall include modifications or replacement of equipment pads and supports. All modifications shall be designed and constructed to conform to the recommendations of *ACI 302.1R-04 Guide for Concrete Floor and Slab Construction* and *ACI 301-10 Standard Specifications for Structural Concrete*. All concrete modifications and repairs shall be coated per the painting/coating section herein.

204.3.9 **Equipment Start Up and performance:**

204.3.9.1 All new equipment installed by the contractor must be started up and be in operational service for 48 hours with no performance issues prior to demolishing and installing like, adjacent equipment in the same system. If the new equipment exhibits any performance issues, the contractor shall repair the equipment/installation as required and begin a new 48 hour observation period.

END OF SECTION
204.4 General Electrical Requirements

204.4.1 Electric Code Compliance: All electrical work shall be performed in compliance with current electrical code.

204.4.2 Electrical Disconnects: All equipment installed or worked on with an electrical portion in the scope of work shall have a new local disconnect switch installed. All local disconnect switches shall be of stainless steel construction meeting NEMA 4X standards. In the event a Class 1, Division 1 rating is required for explosion proof service, the disconnect shall meet all required ratings for Class 1, Division 1 service. Control panels that incorporate an integral disconnect will not be required to have an external disconnect.

204.4.3 Electric Motors: All electric motors shall be premium efficiency, suitable for operating the intended equipment per the equipment manufacturer’s recommendations.

204.4.4 Electrical Wiring, Conduit & Related Items: Contractor shall use caution to avoid damage to existing power cables. These cables shall be reused in new equipment installation provided their reuse meets current code requirements. Contractor shall be responsible for any damage to existing electrical equipment or power cables. The contractor shall be responsible for removing the existing control system and replacing it with the new control system. No unused remnants of the existing control system shall be abandoned in place. Unless noted specifically otherwise, minimum requirements are that all new conduiting shall be threaded rigid connections and sealed between spaces. All conduits shall be sealed with “duct seal” in control panels, motor heads, transitions between spaces in junction boxes and other end device locations for corrosion protection.

204.4.5 Identification: Conduits in manholes, hand-holes, building entrance pull boxes, junction boxes and equipment shall be provided with identification tags. Identification tags shall be 19 gage stainless steel with ½ inch stamped letters and numbers as indicated on the drawings. Identification tags shall be attached to conduits with nylon tie wraps and shall be positioned to be readily visible.

204.4.6 Rigid Steel Conduit shall be heavy wall, plated/hot-dip galvanized, shall conform to ANSI C80.1, and shall be manufactured in accordance with UL 6. Not applicable to this contract unless specifically noted otherwise.
204.4.7 Liquid tight Flexible Metal Conduit shall be hot-dip galvanized steel, shall be covered with a moisture proof polyvinyl chloride jacket, and shall be UL labeled.

204.4.8 Rigid Nonmetallic (PVC) Conduit - PVC conduit shall be heavy wall, Schedule 40, UL labeled for aboveground and underground uses, and shall conform to NEMA TC-2 and UL651. Not acceptable and not applicable to this contract.

204.4.9 Aluminum Rigid Conduit system:

204.4.9.1 The conduit shall be rigid aluminum, threaded, T-1 temper as part of electrical of an all-aluminum conduit system with couplings, bends and fittings as required. Any fasteners and other hardware shall be 316 stainless steel as required and applicable. In the event a Class 1, Division 1 rating is required for explosion proof service, the conduit system shall meet all required ratings for Class 1, Division 1 service. Provide in all interior and exterior installation locations.

204.4.9.2 The conduit system shall be UL 6A and ANSI C80 5 rated for application.

204.4.9.3 Provide “seal-off” corrosion protection at all and panels, device outlets and equipment as recommended by conduit Manufacture.

204.4.9.4 Acceptable manufactures are Wheatland Tube, Republic Conduit, and American Conduit by Sapa or equal.

204.4.9.5 Unless a Manufacture requirements, code or other governing requirement specifically require something other than aluminum conduits, all conduits and accessories shall be aluminum

204.4.10 Conductors. All conductors in power, control and instrumentation circuits shall be identified and color coded as described herein.

204.4.10.1 Conductor Identification Number. Except for lighting and receptacle circuits, each individual conductor in power, control and instrumentation circuits shall be provided with wire identification markers at the point of termination.

204.4.10.2 The wire numbers shall be of the heat-shrinkable tube type, with custom typed identification numbers.

204.4.10.3 The wire numbers shall be as indicated on the equipment manufacturer’s drawings.
204.4.10.4 The wire markers shall be positioned to be readily visible for inspection.

204.4.11 Conductor Color Coding. Power conductors shall be color coded as indicated below. For conductors 6 AWG and smaller, the color coding shall be insulation finish color. For sizes larger than 6 AWG, the color coding may be by marking tape. The equipment grounding conductor shall be green or green with one or more yellow stripes if the conductor is insulated.

204.4.11.1 The following color coding system shall be used for Power conductors:

204.4.11.1.1 120/240V, single-phase – black, red and white
204.4.11.1.2 120/208V, three-phase – black, red, blue and white
204.4.11.1.3 120/240V, three-phase – black, orange, blue and white
204.4.11.1.4 277/480V, three-phase – brown, orange, yellow and gray
204.4.11.1.5 Where 120/240 and 120/208 volt system share the same conduit or enclosure, the neutral for either the 120/240 volt system or the 208 volt system shall be white with a permanent identifiable violet stripe.

204.4.11.2 Control and instrumentation circuit conductors shall be color coded as indicated below:

204.4.11.2.1 Multi-conductor Control Cable: 600 Volt Multi-conductor 14 AWG Control Cable
204.4.11.2.2 REFERENCE: UL 83, UL 1277, ICEA S-73-532, ICEA S-58-679.
204.4.11.2.3 CONDUCTOR: 14 AWG, 7 OR 19 strands, concentric-lay, uncoated copper. Maximum operating temperature 90°C dry, 75°C wet.
204.4.11.2.4 INSULATION: Polyvinyl chloride, not less than 15 mils average thickness; 13 mils minimum thickness, UL 83 Type THHN and THWN.
204.4.11.2.5 SHIELD: None.
204.4.11.2.6 JACKET: Conductor: Nylon, 4 mils minimum thickness, UL 83.

204.4.11.2.7 Cable assembly: Black, flame-retardant polyvinyl, UL 1277, applied over tape-wrapped cable core.

204.4.11.2.8 COLOR IDENTIFICATION: ICEA S-58-679, Method 1, Table 2 or ICEA S-58-679, Method 3, Table 2. White or green conductors shall not be provided. A durable marking shall be provided on the surface of the cable at intervals not exceeding 24 inches. Marking shall include manufacturer’s name, Type THWN or THHN, conductor size, number of conductors, and voltage class.

204.4.12 Signal Control Cable:

204.4.12.1 REFERENCE: UL 62, UL 1277.

204.4.12.2 CONDUCTOR: 16 AWG, 7-strand, concentric-lay, uncoated copper. Maximum operating temperature 90°C dry, 75°C wet.

204.4.12.3 INSULATION: Polyvinyl Chloride, not less than 15 mils average thickness: 13 mils minimum thickness, UL 62, Type TFN.

204.4.12.4 LAY: Twisted pair with 1-1/2 inch to 2-1/2 inch lay.

204.4.12.5 SHIELD: Cable assembly, combination aluminum-polyester tape and 7-strand, 20 AWG minimum size, tinned copper drain wire, shield applied to achieve 100 percent cover over insulation conductors.

204.4.12.6 JACKET: Conductor. Nylon, 4 mils minimum thickness, UL 62.

204.4.12.7 Cable assembly: Black, flame-retardant polyvinyl chloride, UL 1277, applied over tape-wrapped cable core.

204.4.12.8 CONDUCTOR IDENTIFICATION: One conductor black, one conductor white.

204.4.13 Single Conductors: 600 Volt, Single Conductor Power Cable
204.4.13.1 REFERENCE: UL 83, ICEA S-95-658 (NEMA WC 70).

204.4.13.2 CONDUCTOR: Stranded, uncoated copper. Maximum operating temperature 90°C dry, 75°C wet.

204.4.13.3 INSULATION: Polyvinyl, UL 83, type THHN and THWN, ICEA S-95-658.

204.4.13.4 SHIELD: None

204.4.13.5 JACKET: Conductor. Nylon, 4 mils minimum thickness, UL 83.

204.4.14 Sump Pump Control Panels – Unless otherwise noted, Contractor shall provide each unit with the following system components to conform to the following specifications:

204.4.14.1 Input Disconnect: Furnish an input circuit breaker with an interrupting rating of 65,000 rms symmetrical amperes.

204.4.14.2 Control Devices: Include door mounted control and monitoring devices for each sump pump as follows:

A. “Manual-OFF-Auto” control selection

B. Power disconnect

C. Elapsed time meter; shall be non-resettable, rollover at 9999 hours showing resolution of 0.1 hours

D. Phase loss monitor

E. Indicator lamps for Power On, Run, Phase Loss and Overload.

204.4.14.3 NEMA contactors size 1 or larger rated to handle the connected load.

204.4.14.4 Refer to Drawings for control panel schematics for additional requirements.

204.4.14.4 Coil Voltage: 120-volts, 60-hertz.

204.4.15 Variable Frequency Drives (VFD):
204.4.15.1 Enclosures: New VFD units shall be supplied with and installed in a new enclosure. All component enclosures shall be NEMA 12 compliant, and shall fit in the location of replaced equipment.

204.4.15.2 System Features: Contractor shall provide each unit with the following system components to conform to the following specifications:

204.4.15.3 Input Disconnect: Furnish an input circuit breaker with an interrupting rating of 65,000 rms symmetrical amperes

204.4.15.4 The VFD units must comply with all requirements of the existing pumps. The new VFD units shall be 18 pulse "clean power", low harmonic in compliance with IEEE 519 guidelines for harmonic mitigation and have a continuous output current of approximately 30% more than the motor full load nameplate current.

204.4.15.5 New VFD units shall be installed with No cutting, drilling or welding of the new equipment or part thereof as delivered from the manufacturer, for the purpose of adapting or modifying said unit to facilitate its installation, will be permitted without written prior approval by the authority.

204.4.15.6 Control Devices: Include door mounted control and monitoring devices for each drive as follows:

   Start push button

   Stop push button

   "Local-OFF-Remote" control selection

   Maintained Emergency shutdown button – Palm press and red in color

   Speed selection – Door mounted potentiometer operating single turn 0% - 100%

   Frequency meter with hertz and 0-100 scales

   Output ammeter
Elapsed time meter shall be non-resettable, rollover at 9999 hours showing resolution of 0.1 hours

Diagnostic package with fault indication and reset push button

Indicator lamps for the ON, OFF, Auto, Vibration and FAULT unit status conditions

Vibration sensors shall be installed and operated such that when a vibration alarm is triggered, the VFD/Pump shuts down automatically

Vibration sensors shall have the operating capacity of sending a 4-20 mA signal to an analog PLC input and a dry set of contacts for the relay logic

204.4.15.7 PLC Control Features: Furnish a control system for each drive to allow the following Auto/PLC functions:
- Remote, isolated 4-20 mA speed control input
- Isolated 4-20 mA speed output
- PLC Remote Run command
- Alarm outputs
- ON/OFF status output
- Additional features and controls specified with the drive equipment
- Local/Auto status output

204.4.15.8 New and replacement VFDs shall be installed such that all 4-20mA features are available. If a VFD being replaced is not currently configured to communicate with the SCADA system, the replacement unit shall communicate with the SCADA system in the same manner of a new VFD installation. On new VFD installations, all 4-20mA communication features shall be installed in the VFD for future connection to the SCADA system
204.4.15.9  General Purpose Contactors:  Provide general purpose contactors in accordance with NEMA ICS 2 meeting the following:

Coil Voltage: 120-volts, 60-hertz

Poles: Provide three-pole contactors, unless otherwise indicated.

204.4.15.10  Electrical Wiring: Contractor shall be responsible for verifying or replacing all wiring from existing breakers and/or disconnects to the new equipment including replacing breakers as required. All wiring and electrical construction shall meet current electrical code.

204.4.15.11  Complete O&M Manuals and operating parameters shall be supplied on CD. Record drawing shall include PDF drawings showing final routing of power and controls. Reference 204.400.

204.4.15.12  Electrical Wiring & Related Items:

204.4.15.13  All wire to wire connections shall be made using insulated mechanical connectors. All shielded cable shall use heat shrink to cover cable outer cover and shield for termination. No wire nuts or butt splices are to be used unless previous authorization is given by the engineer. Insulated mechanical connectors shall be manufactured by Penn-Union, Galvan Industries, Polaris Electrical Connectors, or an approved equal manufacturer.

204.4.15.14  Power and control wiring will follow the NFPA 79 Chapter 13 standard.

204.4.15.15  Control wiring labeling shall follow NFPA 79 Chapter 13 standard. Control wiring identification tags shall be a thermal transfer print. A Brady TLS2200 or equivalent.

END OF SECTION
204.5 Equipment Painting/Coating

204.5.1 Surface Preparation and Shop Prime Painting: All equipment and disturbed surfaces shall be cleaned and shop primed per equipment manufacturer’s recommendation as part of the work. Equipment nameplates and similar information tags shall be masked off for removal after finish coat applications. All surface preparation for applying a specified coating system shall be done in accordance with the appropriate “Application Bulletin” from the manufacturer for the specific product specified. Provide minimum SP-10 Near white blasting unless Manufacture requirements are more stringent. Equipment vendors/manufactures shall be consulted concerning the required final coating system to insure that it will be compatible with the primer coat applied at the factory, in the event that the shop applied primer coat is not removed prior to the coating installation.

204.5.2 Final Coat: Unless otherwise specified, all new equipment shall be shop or field painted with a final coat, provided all shop painted finish surfaces shall receive matching field touch-up painting as final treatment, all with a finish coat per the equipment manufacturer’s recommendation. All disturbed surfaces shall be field painted after equipment installation with a finish coat per the equipment manufacturer’s recommendation.

204.5.2.1 Disturbed surfaces will be defined as including piping between suction and discharge valves on pump assembly replacements and pipe to either side of valves on individual valve replacements. All other disturbed surfaces will be defined as existing materials adjacent to new equipment.

204.5.3 Coating Systems

204.5.3.1 The Coating System for painting structural steel, piping, valves, etc. not exposed to sunlight shall be Sherwin-Williams Coating System Identification A-1, Alkyd 2-coat system. This system has a primer “KemKromik, Univ. Primer” and a finish coat “Industrial Urethane, Alkyd Enamel” or an approved equal. Contractor shall submit supplier information for approval prior to painting.
204.5.3.2 The Coating System for painting structural steel, piping, valves, etc. non-immersed, mildly corrosive, wet environments and not exposed to sunlight shall be Sherwin-Williams Coating System Identification E-1, *Polymide Epoxy system*. This system has a primer "Macropoxy 646" and a finish coat "Macropoxy 646" or an approved equal. Contractor shall submit supplier information for approval prior to painting.

204.5.3.3 The Coating System for painting metal surface for exterior weathering exposure in a corrosive environment shall be Sherwin-Williams Coating System Identification EU-2, *Urethane Finish, Corrosive Areas 3-coat system or equal*. This system has a primer "Corothane Galvapac", second coat "Macropoxy 646" and a finish coat "Hi-solids Polyurethane" or an approved equal. Contractor shall submit supplier information for approval prior to painting.

204.5.3.4 Coating System for painting metal surface for full or partial immersion service shall be Sherwin-Williams Coating System Identification E-3, *Amine Epoxy Glass Flake Reinforcement or equal*. This is a two-coat system using Sher-Glass Epoxy FF. The first coat shall have a red oxide color with a minimum dry film thickness of 10-15 mils. The second coat shall have a haze gray color. Total dry film thickness shall be a minimum 20-25 mils. Application and total dry film thicknesses shall be installed per Manufacture’s recommendations.

204.5.3.5 Paint color code shall adhere strictly to DEQ code requirements. Paint Color Schedule *(All colors and codes are Sherwin Williams. A crossover for Tnemec and Carboline is available on request.)*:

- Potable Water Flyway SW6794
- Plant Effluent Water (PEW) Blueblood SW6966 w/ Orange bands
- Chilled Water French Roast SW6069 w/ Heartthrob SW6866 bands
- Heating Water Supply Gray Screen SW7071 w/ White bands
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<td>e. Heating Water Return</td>
<td>Gray Screen SW7071 w/ Black bands</td>
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<td>f. Compressed Air</td>
<td>Supreme Green W6442</td>
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<tr>
<td>g. Instrument Air</td>
<td>Supreme Green SW6442</td>
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<td>h. Blower Air</td>
<td>Supreme Green SW6442</td>
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<tr>
<td>i. Natural Gas</td>
<td>Hearththrob SW6866</td>
</tr>
<tr>
<td>j. Sludge Return</td>
<td>Bagel SW6114</td>
</tr>
<tr>
<td>k. Sludge Waste</td>
<td>Sensational Sand SW6094</td>
</tr>
<tr>
<td>l. Digested Sludge</td>
<td>French Roast SW6069</td>
</tr>
<tr>
<td>m. Sludge Sample</td>
<td>Web Gray SW7075 w/ Hearththrob SW6866 bands</td>
</tr>
<tr>
<td>n. Drain/Sump</td>
<td>Web Gray SW7075</td>
</tr>
<tr>
<td>o. Raw Sewage</td>
<td>Software SW7074</td>
</tr>
</tbody>
</table>

204.5.3.6. If the equipment or piping being painted does not fall under any of these categories, the contractor shall make the best color match to the materials being replaced and adjacent like materials after submittal of color selection for acceptance.

204.5.3.7. PEW System specific requirements: All PEW System piping, valves, supports, operators, couplings and miscellaneous shall be color coded and marked as follows.

a. Color Coding: Topcoat shall be Purple (Pantone 522) per the Oklahoma Department of Environmental Quality (DEQ) Title 252, Chapter 656, Section 252:656-27-4. In addition, piping shall have orange bands that are six (6) inches wide and spaced along the pipe at five (5) foot intervals.

b. Lettering: The following language: **“CAUTION: RECLAIMED WATER-DO NOT DRINK.”** shall be provided on the pipe near the equipment served, adjacent to valves, at each branch or tee, and at least every 50 feet in straight runs of pipe and be per Department of Environmental Quality (DEQ) Title 252, Chapter 656, Section 252:656-27-4. Lettering shall be painted or stenciled on piping or shall be applied as snap-on markers.
Snap-on markers shall be plastic sleeves, Brady "Bradysnap-On B-915" or Seton "Setmark" Lettering shall be white. Reference Table 1 for lettering size requirements.

c. Flow Arrows: PEW System piping shall not have flow arrows.

204.5.3.8 After painting, any labeling or tags covered by the paint shall be re-applied, updated or uncovered such that all labels are readable and clearly identifies the system. In the event of new piping or equipment replacing piping or equipment with labeling, the new equipment shall be labeled to match the existing. Marking and signage shall be applied once area painting is complete as part of the schedule of value item.

204.5.3.9 Equipment supplied from the manufacturer with an epoxy coating or manufactured from a corrosion resistant material (stainless steel, etc…) shall not be painted/coated after installation.

204.5.3.10 Factory applied epoxy coating systems shall be in the following thicknesses unless noted otherwise per Manufacturer’s recommendations:

   a. Primer Coat *3.0 to 5.0 mils
   b. Finish Coat *4.0 to 6.0 mils

   *Note – Per manufactures Recommendations.

204.6 Concrete Coating

204.6.1 Materials: Concrete coating shall be Sikagard 62, Raven 405, Sauereisen SewerGard No. 210, or an approved equal to protect concrete and concrete repairs from H₂S and other corrosive elements found in wastewater process facilities. Epoxy coating to be applied according manufacturer’s installation instructions and shall extend beyond repair areas by a minimum of 6”. All concrete coating products shall be handled and stored in the manner set forth in the manufacturer’s installation instructions.

204.6.2 Surface Preparation: Concrete surfaces to receive coating shall be inspected prior to surface preparation to determine the condition of the surfaces specified to receive the coating product(s) and the appropriate method or combination of methods to be used for surface preparation to meet the requirements of the coating system(s) to be applied per manufacturer’s instructions. Minimum metal
surface preparation for the project in areas to receive paint or coatings shall be SP 10, near white blasted.

204.6.2.1 Oils, grease, incompatible existing coatings, waxes, form release, curing compounds, efflorescence, sealers, salts, or other contaminants which may affect the performance and adhesion of the coating to the substrate shall be removed per ASTM D-4258.

204.6.2.2 Efforts shall be made to minimize the change of holidays and coating thin areas by this contract. Concrete fins, protrusions, burrs, sharp edges and concrete spatter shall be corrected by grinding or scraping. Concrete bug holes and other small voids shall be filled with a non-shrink grout limited to each hole or void. A full grout rub of the wall is not allowed unless specifically approved by the Engineer.

204.6.2.3 Unless otherwise submitted and approved by the Engineer, surfaces to receive coating shall be abrasive blasted per ASTM D-4259 to remove laitance and weak concrete to expose subsurface voids, open honeycomb and air pockets. After blasting, surfaces shall be cleaned of all loose blast grit, dust and other debris by sweeping, vacuuming, air blasting and washing as necessary.

204.6.2.4 Surface preparation method(s) used shall be performed in a manner that provides a uniform, sound clean neutralized surface suitable for the specified coating product(s).

204.6.2.5 Infiltration shall be stopped by using a material which is compatible with the repair products and is suitable for top coating with the coating product(s).

204.6.2.6 Where defective concrete is encountered requiring repair at the direction of the Engineer refer to Specification Section 204.7 Concrete Rehabilitation for requirements.

204.6.3 Application of coating products: Application procedures shall conform to the recommendations of the coating product(s) manufacturer, including
environmental controls, product handling, mixing, application equipment and methods.

204.6.3.1 Prepared surfaces shall be primed by application of the waterborne epoxy primer described herein at an application rate of 200 square feet per gallon (8 mils wet film thickness). The primer shall be allowed to dry to a tack free state. The solvent-free epoxy topcoat described herein shall then be spray applied to a minimum wet film thickness of 80-100 mils.

204.6.3.2 No more than 12 hours shall be permitted to pass between each application of the waterborne epoxy, the solvent-free epoxy primer and the epoxy topcoat. Subsequent top coating or additional coats of the coating product(s) shall occur within the products recoat window as adjusted for temperature extremes. Additional surface preparation procedures will be required if this recoat window is exceeded.

204.6.3.3 Coating product(s) shall interface with adjoining construction materials throughout the structure to effectively seal and protect concrete substrates from infiltration and attack by corrosive elements. Procedures and materials necessary to effect this interface shall be as recommended by the coating product(s) manufacturer.

204.6.4 Submittals: The Contractor shall submit the following to the Engineer, in accordance with this Specification:

- Product data sheets and installation procedures for proposed concrete repair mortar(s).

- Detailed design notes, calculations and Shop Drawings for any temporary works, including formwork and falsework.

204.7 Concrete Rehabilitation
204.7.1 **Description:** The Work shall consist of:

- Removing the deteriorated concrete as shown and described on the Drawings and in this Specification, including saw cutting the perimeter of the repair area.
- Preparing the surface of the concrete for the repair, including abrasive cleaning, cleaning of existing reinforcement, and applying bonding agent to the surface.
- Supplying materials and the mixing and placing of concrete repair mortar or concrete as shown and described on the Drawings and in this Specification including vibrating, finishing and curing.
- Supplying, fabricating, constructing, maintaining and removing temporary works, including falsework and formwork.

204.7.2 **Submittals:** The Contractor shall submit the following to the Engineer, in accordance with this Specification:

- Product data sheets and installation procedures for proposed concrete repair mortar(s).
- Detailed design notes, calculations and Shop Drawings for any temporary works, including formwork and falsework.

204.7.3 **Materials:** The Contractor shall supply all materials necessary for the repair and restoration of deteriorated concrete areas as follows:

204.7.3.1 **Acceptable Manufacturers:**

a. Sika MonoTop 611, as manufactured by Sika Corporation, Lyndhurst, New Jersey, and Quadex QM-1s Restore, as manufactured by Quadex, North Little Rock Arkansas, are considered to conform to the requirements of this specification and has performed satisfactorily for patching or overlaying for a minimum of three years.
b. Substitutions: The use of other than the specified product will be considered providing the contractor requests its use in writing to the Engineer. This request shall be accompanied by:

- A certificate of compliance from an approved independent testing laboratory that the proposed substitute product meets or exceeds the specified performance criteria, tested in accordance with the specified test standards; and
- Documented proof that the proposed substitute product has a three year proven record of performance of patching or overlaying, confirmed by actual field tests and five successful installations that the Engineer can investigate.

Certification from the manufacturer demonstrating compliance with the ISO 9000 quality standard in the development, manufacture, and sale of the product.

204.7.3.2 Performance Criteria Typical Technical Data

a. Typical Properties of the mixed polymer-modified portland cement mortar:
   - Working Time: approximately 30 minutes
   - Finishing Time: 30-60 minutes
   - Color: concrete gray

b. Typical Properties of the cured polymer-modified portland cement mortar:
   - Compressive Strength (ASTM C-109)
     - 1 day: 3,000 psi
     - 7 day: 5,500 psi
     - 28 day: 6,500 psi
   - Splitting Tensile Strength (ASTM C-496) at 28 days: 500 psi
   - Flexural Strength (Modulus of Rupture)(ASTM C-78) at 28 days: 720 psi
   - Bond Strength (ASTM C-882 Modified) at 28 days: 2200 psi
• Chloride ion permeability (AASHTO T-277): < 600 coulombs
• The silica fume, polymer-modified portland cement mortar shall not produce a vapor barrier.

204.7.3.3 Materials

a. Silica-fume, Polymer-modified portland cement mortar:

• The mortar shall be a silica fume-enhanced, polymer-modified composition containing a blend of selected cements, plasticizing/water-reducing admixtures and shrinkage compensating agents.
• The material shall be non-combustible, either before or after cure.
• The silica fume, polymer-modified portland cement mortar shall be supplied in a factory proportioned unit.
• The silica fume, polymer-modified portland cement mortar must be placeable from 3 inches in depth and extendable in greater depths.

b. To prepare the silica fume, polymer-modified portland cement concrete (for pumping): the factory proportioned unit may be extended with 34-36 lbs. of a minus 1⁄4 in. clean, well-graded, saturated surface dry aggregate, having low absorption and high density. Aggregate shall conform to ASTM C-33.

c. Materials for forming, as required for the designated work, shall be approved by the Engineer.

204.7.4 Construction Methods

204.7.4.1 Surface Preparation Prior to any concrete repairs, the Contractor shall remove all dust, dirt, water and debris from the surface of the concrete in a manner that will not result in the material being deposited into the channel or onto the underlying ground surface below. The Contractor shall supply and erect appropriate protection barriers/shrouding or other approved means as required on the
bridge deck or piers so as to completely contain all loose or flying debris from the surface removal preparations. The means of containment shall be subject to the approval of the Engineer. No debris shall fall into the channel or onto any underlying roadway or ground surfaces.

204.7.4.2 Concrete Removal All areas of unsound concrete to be repaired will be marked by the Engineer once the Contractor has cleaned the existing surface as per Section 204.6.2 of this Specification. The Contractor shall saw cut the outer perimeter of the repair areas 1” deep or as directed by the Engineer. Feathered edges will not be acceptable. The Contractor shall take care to ensure that the existing reinforcing steel or prestressing strands (if applicable) are not damaged during saw cutting. Any damage caused by the Contractor to any portion of the structure not intended for repair shall be repaired by the Contractor, at the Contractor’s expense, to the satisfaction of the Engineer. The Contractor shall remove all areas of unsound concrete by chipping or other approved methods. Only chipping hammers of the 20 lb class or less shall be used, and operated at an angle of 45 degrees or less from the horizontal. The Contractor shall exercise caution and take care not to damage any existing reinforcing steel intended to remain in place.

204.7.4.3 Types of Repairs Concrete repairs will be classified as follows:

a. Type A Partial Depth Concrete Repair – A Type A repair is defined as removal of unsound concrete to a depth not greater than the top of the existing reinforcing steel. The Contractor shall remove all unsound concrete from the areas as determined by the Engineer until a sound concrete substrate is exposed.

b. Type B Partial Depth Concrete Repair – A Type B repair shall be defined as removal of unsound concrete to a depth a minimum of 1” beyond the existing outer mat of reinforcing steel. For substructure, girder or mass concrete repairs the maximum depth shall be 2” beyond the existing outer mat of reinforcing steel.
The Contractor shall supply and place additional reinforcing steel as directed by the Engineer when the existing reinforcing steel has a section loss of 25% or greater. The reinforcing steel shall be of the same type and size as the existing, and spliced with a minimum lap length of 30 bar diameters. Exposed reinforcing steel shall be sandblasted clean and maintained to a near white condition. The Contractor shall roughen all areas of the existing sound concrete substrate to a \( \frac{1}{4} \)” amplitude using methods acceptable to the Engineer. All resulting material and by-products from demolition operations shall be collected, loaded, hauled, and disposed of by the Contractor at an approved waste disposal facility. Costs for reinforcing steel shall be considered incidental and included in other portions of the work.

Surface Preparation Immediately prior to placing the repair mortar or concrete, the Contractor shall thoroughly clean the existing concrete surfaces and formed repair areas, and apply a low resistivity bonding agent or cement slurry as recommended by the repair mortar manufacturer or as directed by the Engineer.

Repair Mortar Placement and Finishing The concrete repair mortar shall be handled, stored, mixed and applied in accordance with the manufacturer's instructions. Immediately prior to placing the repair mortar, the Contractor shall thoroughly clean the existing concrete surfaces and formed repair areas, and apply a low resistivity bonding agent or cement slurry as recommended by the repair mortar manufacturer or as directed by the Engineer. The Contractor shall place the repair mortar such that the existing profile and cross section are restored to their original dimensions. Any deviations of \( \frac{1}{4} \)” or greater from the repaired areas to the existing surface shall be repaired by the Contractor at his expense to the satisfaction of the Engineer. If the existing or repair concrete surface is damaged in any way by construction operations, or if the concrete repair shows signs of distress or scaling prior to final acceptance, it shall be repaired or replaced by the Contractor at his own expense. The
Contractor shall finish the repair surface in accordance with the concrete coating manufacturer’s requirements.

204.7.4.7 Curing shall be in accordance with the manufacturer’s instructions or as otherwise directed by the Engineer.

204.7.5 Quality Management

204.7.5.1 General Concrete repair mortar that is not stored, handled, prepared, placed, or cured in accordance with the manufacturer’s instructions will be rejected by the Engineer and his/her decision shall be considered final. The Engineer reserves the right to require immediate removal of any concrete from rejected batches that may have already been placed in the structure. Quality assurance testing will be carried out by the Engineer and all associated costs will be paid for by the Owner. There shall be no charge to the Owner for materials taken by the Engineer for testing purposes.

204.7.6 Method of Measurement

204.7.6.1 Concrete Repairs Concrete repairs will be measured on a surface area basis. The area to be paid for will be the total number of square feet of concrete repaired in accordance with this specification as computed from measurements made by the Engineer.

204.7.7 Basis of Payment

2.4.7.7.1 Type A Partial Depth Concrete Repair – Type A Partial depth concrete repairs will be paid for at the Contract Unit Price per square foot for “Type A Partial Depth Concrete Repair”, measured as specified herein, which price will be payment in full for performing all operations herein described and all other items incidental to the Work.

204.7.7.2 Type B Partial Depth Concrete Repair – Type B Partial depth concrete repairs will be paid for at the Contract Unit Price per square foot for “Type B Partial Depth Concrete Repair”, measured as specified herein, which price will be payment in full for performing all operations herein described and all other items incidental to the Work.
PART 1 - GENERAL

1.1 STANDARDS

A. Concrete work shall conform to all requirements of ACI 301-89 "Specifications for Structural Concrete for Buildings", ACI 350 "Code Requirements for Environmental Engineering Concrete Structures", ACI 318-89 "Building Code Requirements for Reinforced Concrete" except as modified herein.

B. All referenced standards shall be the latest editions.

1.2 SCOPE

A. Work consists of furnishing all plant, labor, materials, equipment and appliances, and performing all operations in connection with installation of the concrete work, complete, in strict accordance with the Specifications and Drawings.

1.3 INSPECTION

A. Embedded items must be inspected and tests for concrete and other materials shall have been completed and approved by the Engineer before concrete is placed.

1.4 SLAB ON EARTH

A. Before proceeding to construct concrete slabs on earth, all pipes under concrete floor on earth shall have received the required tests. All backfill and fill material under slabs on grade shall be compacted in 6” layers to 95% maximum density as measured by AASHTO T99 test method. Unsuitable material encountered in subgrade shall be removed and replaced with material approved by the Engineer. Subgrade shall be brought to true, even plane and compacted to solid bearing. Gravel drainage fill shall be placed and compacted where shown on Drawings.

PART 2 - MATERIALS

2.1 All concrete materials shall conform to the latest revised ASTM Designations listed below and shall be subject to the approval of the Engineer:
A. Coarse Aggregate shall be crushed stone conforming to ASTM C-33 with a maximum size of 1".

B. Fine Aggregate shall conform to ASTM C-33 and shall be washed river sand composed of clean, uncoated grains of strong materials.

C. Cement shall be Portland cement conforming to ASTM Specification C-150, Type V. Only one brand of cement shall be used for exposed concrete.

D. Water: Clean, fresh and free from oil, acids, alkali, vegetable, sewage, organic or other deleterious matter.

E. Air-Entraining Admixtures shall conform to ASTM C-260.

G. Premolded Expansion Joint Filler Strips shall be non-extruding type conforming to the current AASHTO Designation M213.

H. Non-Shrink Grout shall be Pre-mixed "Embeco" as manufactured by Master Builder's, "Ferrolith G" as manufactured by Sonneborn-Contech, or approved equal. Type as recommended by the manufacturer for the particular applications.

I. Liquid Curing Compound/Sealer shall be "MC 429" as manufactured by Master Builder's, "Kure-N-Seal" as manufactured by Sonneborn-Contech, "Thompson's Water Seal" as manufactured by E. A. Thompson, Inc. or approved equal.

J. Granular Drainage Fill: Required under all interior building concrete slabs on grade and where noted on the drawings. It shall be either:

1. Clean, washed gravel with particle sizes grading from maximum of 1" down to not more than 5% passing a No. 4 sieve.

2. Clean, washed coarse sand with particular sizes ranging from pea gravel down to largest grains permitted in concrete sand.

K. Joint Waterproofing for existing structures or as required on the plans shall be Ironite (Metallic) Waterproofing as manufactured by the Ironite Company of Chicago, Illinois or approved equal.
L. Vapor Barrier required under all interior concrete slabs on grade and where noted in drawings shall be polyethylene sheet, 6 mil thickness conforming to ASTM E-154.

M. Liquid Chemical Hardener shall be the magnesium fluosilicate and zinc fluosilicate type "Lapidolith" as manufactured by Sonneborn-Contech, Inc., "Symons Quad Cure" as manufactured by Symons Corp., "Hornolith" as manufactured by W. R. Grace & Co., or approved equal.

N. Cementitious Waterproofing and Finish Compound shall be "Thoroseal Plaster Mix" with "Acryl 60" as manufactured by Standard Dry Wall Products or equal.

2.2 QUALITY AND CONTROL

A. Design

Concrete shall be composed of Portland cement, fine aggregate, coarse aggregate and water. All concrete shall be designed by an independent testing laboratory, approved by the Engineer, in accordance with the A.C.I. Standard "Recommended Practice for Selecting Proportions for Concrete" (ACI 211) to produce the strength for each class of concrete specified, and with slumps and maximum sizes of coarse aggregate in accordance with the requirements outlined below. The concrete shall be so designed that the concrete materials will not segregate and excessive bleeding will not occur. Submit laboratory trial mix designs and test results for each class of concrete to be used to the Engineer for approval before any concrete is placed. Any costs of the testing laboratory for designing concrete mixes shall be borne by the Contractor. Concrete strengths shall be as follows:

Class A Concrete - 4000 psi minimum @ 28 days (Air entrained) - six (6) sacks cement minimum

Class B Concrete - 3000 psi @ 28 days - five (5) sacks cement minimum

Class C Concrete - 2000 psi @ 28 days

Class D Concrete - 3000 psi @ 28 days (3/8" Max. Aggregate Size "Pea Gravel")
MAXIMUM SLUMPS FOR VARIOUS TYPES OF CONSTRUCTION

<table>
<thead>
<tr>
<th>Types of Construction</th>
<th>Hand Placed Maximum</th>
<th>High Frequency Vibrator Used - Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reinforced Foundation, Footings and Base Slabs of Tanks</td>
<td>5&quot;</td>
<td>3&quot;</td>
</tr>
<tr>
<td>Slabs, Beams and Reinforced Walls</td>
<td>6&quot;</td>
<td>5&quot;</td>
</tr>
<tr>
<td>Building Columns</td>
<td>6&quot;</td>
<td>5&quot;</td>
</tr>
<tr>
<td>Pavements, curb and sidewalks</td>
<td>3&quot;</td>
<td>3&quot;</td>
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</tbody>
</table>

The slump shall not exceed the maximum specified above for the type of construction for which it is to be used. The 28 day compressive strength determined in accordance with current ASTM Specifications C-39 and C-31 and with specimens cured in accordance with C-31 shall not be less than that shown above for the specified class of concrete. No water will be added after the amount specified by the mix design.

B. Production of Concrete

All ready-mix concrete shall be batched, mixed and transported in accordance with "Specifications for Ready-Mixed Concrete (ASTM C-94)". Plant equipment and facilities shall conform to the "Check List for Certification of Ready-Mixed Concrete Production Facilities" of the National Ready-Mixed Concrete Association. Site mixed concrete shall conform to the requirements of "Specifications for Structural Concrete" (ACI 301). The Contractor may elect to use either ready-mixed or site mixed concrete for this project provided he informs the Engineer of his choice.

C. Laboratory Testing

The Owner shall engage an independent testing laboratory to conduct concrete tests. Contractor will be responsible for sampling concrete for test cylinders, recording, and delivering them to the laboratory, providing all materials required, and for making all slump tests in the field directed by the Engineer. All costs in connection with work performed by the laboratory will be paid by the Owner. The Contractor shall be responsible for the costs of work performed by the laboratory required for redesign of concrete proportions and additional testing of in place concrete when cylinders indicate
low strength concrete has occurred.

At least one test shall be made on fresh concrete for each one hundred (100) cu. yds. of each class of concrete (or fraction thereof) placed on any one day and in any event, not less than one test for each class of concrete each day it is used. Testing shall be done in accordance with the following ASTM Specifications, latest edition:

C172- Standard Method of Sampling Fresh Concrete

C31 - Standard Method of Making and Curing Concrete Compression and Flexure Test Specimens in the Field

C39 - Standard Method of Test of Compressive Strength of Molded Concrete Cylinders

C143- Standard Method of Slump Test for Consistency of Portland Cement Concrete

Before any concrete is poured, the Contractor shall construct a storage box in accordance with ASTM Specification C31. Each set of tests shall consist of one slump test and four compression test cylinders. All cylinders shall be kept in the storage box for the first 24 hours. The four cylinders shall be laboratory cured and tested for adequacy of the design for strength of the concrete in accordance with ASTM Specification C31. One cylinder shall be tested at 7 days and two at 28 days.

The fourth cylinder will be retained for subsequent testing if required by the Engineer.

D. Failure of Concrete to Meet Strength Requirements: The concrete shall be considered acceptable if, for any one class of concrete, the average of all tests of any five consecutive sets is equal to or greater than the specified strength, provided that no more than one test in ten falls between 90% and 100% of the specified strength. The only cylinders to be used for determination of concrete acceptability will be those laboratory cured and tested at 28 days. When it appears the tests of laboratory-cured cylinders will fail to meet these requirements, the Engineer may require changes in the proportions of concrete for the remainder of the work in order to meet the strength requirements. In addition, the Engineer may also require additional curing on portions of the concrete already poured.

The Engineer may also require tests in accordance with Methods of Securing, Preparing
and Testing Specimen from Hardened Concrete for Compressive and Flexural Strengths (ASTM Specifications C42) when the concrete cylinder tests fail to meet strength requirements. In the event there still is question as to the quality of the concrete in the structure, the Engineer may require load tests for that portion where the questionable concrete has been placed. Such load tests will be made as outlined in American Concrete Institute Building Code, (ACI 318), and shall be at the expense of the Contractor. In-place testing shall be at the expense of the Contractor.

E. Removal of Under Strength Concrete: If the above tests indicate that a particular batch of previously placed concrete is under strength, the Engineer may direct that the under strength batch be removed and replaced. The removal of the under strength concrete shall also include the removal of concrete that has obtained the required strength if the Engineer deems this necessary to obtain structural or visible continuity when the concrete is replaced.

The removal, and replacement of any under strength concrete, shall be made at no additional cost to the Owner. This shall include any new formwork required or any reinforcing steel that may be required. The Owner shall not be charged any additional costs for any extra work that is required because of the failure of any concrete to meet the minimum test requirements.

F. Concrete Strengths: The various strengths of concrete shall be installed as follows:

1. Class A, 4000 psi, Air-Entrained shall be used for all liquid containing and non-liquid containing structures, (footings, driveways, slabs, walls, columns and roofs.)

2. Class B, 3000 psi shall be used for sidewalks, curbs and thrust blocking.

3. Class C, 2000 psi shall be used for all non-structural fill concrete, mud slabs, over excavation concrete and other selective backfill conditions as approved by the Engineer.

4. Class D, 3000 psi pea gravel concrete (maximum aggregate size of 3/8") shall be used for all masonry fill, masonry columns cells, and masonry bond beams.

PART 3 - INSTALLATION
3.1 PREPARATION BEFORE PLACING

A. Water shall be removed from excavations before concrete is deposited. Hardened concrete, wood chips, shavings, and other debris shall be removed from interior of forms and inner surfaces of mixing and conveying equipment. Wood forms shall be oiled or, except in freezing weather, wetted with water in advance of pouring. Reinforcement shall be secured in position, inspected and approved by the Engineer before starting pouring of concrete.

3.2 CONVEYING

A. Concrete shall be conveyed from mixer to forms as rapidly as practicable and by methods, which will prevent segregation or loss of ingredients. It shall be deposited as nearly as practicable in its final position. Chutes used shall be such that concrete slides in them and does not flow. Chutes, if permitted, shall have a slope of less than 1 on 2. Where a vertical drop greater than five (5) feet is necessary, placement shall be through elephant trunks or similar devices to prevent segregation. Ready-mixed concrete shall be delivered with a load ticket showing mix proportions and the time mixing began for each load. The load ticket shall be furnished to the Engineer.

3.3 PLACING

A. Concrete shall be placed before initial set has occurred and in no event after it has contained its water content for more than 30 minutes for site mixed concrete or 1 hour for ready-mixed concrete. Unless otherwise specified, all concrete shall be placed upon clean, damp surfaces free from running water, or upon properly consolidated fills, but never upon soft mud or dry, porous earth. Deposit concrete continuously or in layers of such thickness that no concrete will be placed on concrete which has hardened sufficiently to cause the formation of seams or planes of weakness within the section.

B. If a section cannot be placed continuously, provide construction joints as herein specified. The concrete shall be compacted and worked in an approved manner into all corners and angles of the forms and around reinforcement and embedded fixtures as to prevent segregation of the coarse aggregate. Construction of forms for the lifts of vertical walls shall be such as to make all parts of the walls easily accessible for the placement, spading, and consolidation of the concrete as specified herein.
C. No “finished water” shall be surface applied during finishing efforts.

D. Curing methods shall be submitted to the Engineer and applied per manufacture’s recommendations.

3.4 VIBRATION

A. All concrete shall be placed with the aid of mechanical vibration equipment as approved by the Engineer. Vibration shall be transmitted directly to the concrete; in no case shall it be transmitted through forms. The duration of vibration at any location in the forms shall be held to the minimum necessary to produce thorough compaction. Vibrations shall be supplemented by forking or spading by hand, and adjacent to the forms on exposed faces in order to secure smooth, dense and even surfaces, with particular care being taken to prevent coarse aggregate from becoming set too near any surfaces that are to receive rubbed finish.

3.5 CONSTRUCTION JOINTS

A. Construction joints shall be formed as indicated on the drawings or as approved or directed by the Engineer. Contractor shall submit a joint location plan for each structure to the Engineer for approval 28 days prior to commencing concrete operations on that structure. Where indicated or required, dowel rods shall be used. All concrete at the joints shall have been in place not less than 12 hours, and longer if so directed by the Engineer, before concrete resting thereon is placed. Before placing is resumed, or commenced, excess water and laitance shall be removed, and concrete shall be cut away, where necessary, to insure a strong dense concrete at the joint. In order to secure adequate bond, the surface of concrete already in place shall be cleaned, roughened, and then spread with a one-half (½) inch layer of mortar of the same cement-sand ratio as is used in the concrete, immediately before the new concrete is deposited. The unit of operation is not to exceed 40 feet in any horizontal direction, unless otherwise required by the Drawings. Construction joints, if required, shall be located near the mid-point spans for slabs, beams or girders. Joints in columns or piers shall be made at the underside of the deepest beam or girder at least five (5) hours before any overhead work is placed thereon. Joints not shown or specified shall be so located as to least impair strength and appearance of work. Vertical joints in wall footings shall be reduced to a minimum. Placement of concrete shall be at such a rate that surfaces of concrete not
carried to joint levels will not have attained initial set before additional concrete is placed thereon.

B. Girders, beams and slabs shall be placed in one operation. To insure a level straight joint in exposed vertical surfaces, a strip of dressed lumber may be tacked to the inside of the forms at the construction joint. The concrete shall be poured to a point one (1) inch above the underside of the strip. The strip shall be removed one (1) hour after concrete has been placed and any irregularities in the joint line leveled off with a wood float and all laitance removed. Waterstops shall be installed in all construction joints below grade or in liquid containing structures as noted on the Plans. Install as per SECTION 3.3, CONSTRUCTION JOINTS, EXPANSION JOINTS, & WATERSTOPS.

3.6 PATCHING

A. Any concrete which is not formed as shown on the Plans, or for any reason is out of alignment or level or shows a defective surface shall be considered as not conforming with the intent of these Specifications and shall be removed from job by Contractor at his expense, unless the Engineer grants permission to patch defective area, which shall be done in accordance with the following procedure. Permission to patch any such area shall not be considered a waiver of the Engineer's right to require complete removal of defective work if patching does not, in his opinion, satisfactorily restore quality and appearance of surface. Suitable non-shrink, latex or epoxy mortar shall be used for patching and repairing defective surface if permitted by the Engineer.

B. After removing forms, all concrete surfaces shall be inspected and any poor joints, voids, stone pockets, all tie holes, or other defective areas shall be patched, if permitted by the Engineer. Where necessary, defective areas shall be chipped away to a depth of not less than one (1) inch with edges perpendicular to the surface. Area to be patched and a space at least six (6) inches wide entirely surrounding it shall be wetted to prevent absorption of water from the patching mortar. A grout of equal parts Portland cement and sand, with sufficient water to produce a brushing consistency, shall then be well brushed into the surface followed immediately by the patching mortar. The patch shall be made of the same material and of approximately the same proportions and shall not be richer than 1 part cement to 3 parts sand. White Portland cement shall be substituted for a part of the gray Portland cement to match color of the surrounding concrete. The proportion of white and gray cements shall be determined by making a trail patch. The amount of mixing water shall be as little as consistent with the requirements of handling and placing.
The mortar shall be retempered without the addition of water by allowing it to stand for a period of one (1) hour during which time it shall be mixed occasionally with a trowel to prevent setting.

C. The mortar shall be thoroughly compacted into place and screened off so as to leave patch slightly higher than surrounding surface. It shall then be left undisturbed for a period of 1 to 2 hours to permit initial shrinkage before being finally finished. The patch shall be finished in such a manner as to match the adjoining surface. On surfaces where unlined forms have been used, the final finish shall be obtained by striking off the surface with a straightedge spanning the patch and held parallel to the direction of the form marks.

D. Tie holes left by withdrawal of rods or the holes left by removal of ends of ties shall be filled solid with non-shrink grout after first being thoroughly wetted within 7 days of placement and prior to any area backfill.

3.7 SLAB FINISHES

A. Exterior Concrete Walks:

After thoroughly consolidating the concrete the top surface shall be struck off with a straight edge and tamped or vibrated sufficiently to bring mortar to the surface. Finish with a wood float to a smooth, even surface and lightly broomed to provide "slip resistant" surface. Edges shall be rounded with a 1/4" radius.

B. Interior slabs to receive grout fill or mortar setting bed shall be finished by tamping concrete with special tools to force coarse aggregate below the surface, and screened with straightedges to bring surface to finish plane with a tolerance not exceeding 1/8" in 2 feet. Surface shall be left roughened sufficiently to produce good bond with topping material. Use stiff brushes, brooms or rakes as necessary to provide 1/8 inch deep grooves at maximum of ½ inch on center.

C. Top and bottom slabs of all structures and water carrying conduits except as noted otherwise on the Plans shall be finished as follows: The top of the slab shall be screened to grade and cross section; lightly tamped as required to bring up a good bed of mortar for finishing and re-screened as necessary. The surface shall then be finished with a wood float and leveling darby. No further finish will be required on top slabs of structures.
or conduits, which are to be buried. In the case of all exposed top slabs of structures and conduits, they shall be given a final wood float and a lightly broomed, slip resistant finish to a uniform surface, which conforms with accuracy to required shape, slope and grade. Slabs shall be edged as appropriate. No liquid hardener is to be applied to these surfaces.

D. Interior floor slabs that are not to receive any finish floor covering shall be "slip resistant finish" as follows: The top surface shall be steel troweled and have a final finish applied by brushing lightly with a soft bristle brush to form a slightly roughened surface.

E. Liquid Hardener shall be applied to the floors where scheduled to be exposed concrete. Concrete surfaces to be treated must be thoroughly set and dry, clean and free of dust. Three applications of the liquid hardener are required, using one gallon per 100 square feet for the complete treatment. Apply hardener strictly according to the manufacturer's printed instructions. Liquid floor hardener is not required when a minimum of two (2) coats of Thompson's Waterseal or equal has been used as a curing and/or separating compound. Submit material and method to be used for Engineer's approval.

3.8 FINISH OTHER THAN SLABS

A. All top surfaces, other than slabs, not covered by forms, and which are not to be covered by additional concrete or fill shall receive a wood float finish without additional mortar. Care shall be taken that no excess water is present when the finish is made. Other surfaces shall be brought to finished elevations and left true and regular. All exposed top surface interior concrete shall be grouted smooth and given a cement wash of one part light colored Portland cement and two parts fine aggregate mixed with water to consistency of thick paint. Grout shall be cork or wood floated to fill all pits, air bubbles, and surface holes. Excess grout shall be scraped off with a trowel and rubbed with burlap to remove any visible grout film. Surface shall be kept damp during setting period. The finish for any area shall be completed in the same day and the limits of a finished area shall be made at natural breaks in finished surface. Painting of exposed-to-view concrete surfaces is specified under SECTION 9.1 - PAINTING of these Specifications.

B. Rubbed Finish:

Unless otherwise indicated, all faces (except top surfaces of slabs) exposed to view, such as walls, grade beams, columns, beams, walls of water carrying conduits to a point 1'-0"
below normal water level, canopy soffits and fascias, etc. shall be finished as follows:

Forms shall be removed, as specified in SECTION - CONCRETE FORMWORK, and all fins removed, off-sets leveled, damaged places and depressions resulting from the removal of metal ties or other causes shall be carefully pointed with a mortar of sand and cement in the proportion which has been employed for the particular class of concrete treated. The surface film of all such pointed places shall be carefully removed before setting occurs. After the point has set sufficiently to permit it, all exposed surfaces shall be dampened and rubbed with a No. 16 Carborundum stone, to a smooth even plane. Final rubbing shall be done with a No. 30 Carborundum stone, or an abrasive of equal quality, to obtain an entire surface of a smooth texture and uniformity in color. Mortar or grout worked up during rubbing shall be promptly removed by sacking with burlap or other suitable means so that no visible grout film or paste will remain. A cement wash or plaster coat shall not be used. All surfaces shall be finished uniformly smooth and washed clean. The rubbed finish for any area shall be completed in the same day and the limits of a finished area shall be made at natural breaks in the finished surface. If the Contractor does not provide suitable surface finish using Carborundum stones specified above, the Engineer, without additional cost to the Owner, may require the use of a power operated grinding machine or other methods to produce the desired finish.

C. Cementitious Waterproofing and Finish:

As an option to the rubbed finish, as specified herein, all faces (except top surfaces of slab) exposed to view, such as walls, grade beams, columns, beams, canopy soffits and facias, etc., shall be finished using “Thoroseal” coating or approved equal as described in the following paragraphs.

1. General

Forms shall be removed, as specified in SECTION 3.4 - CONCRETE FORMWORK, and all fins removed, off-sets leveled, damaged places and depressions resulting from the removal of metal ties or other causes shall be carefully pointed with a mortar of sand and cement in proportion which has been employed for the particular class of concrete treated. The surface film of all such pointed places shall be carefully removed before setting occurs. After the point has set sufficiently to permit it, all exposed surfaces shall receive the following treatment.
2. Mixing

Thoroseal plaster mix shall be prepared using a solution composed of not less than one part Acryl 60 (approximately two quarts Acryl 60 per bag) and three parts of clean, potable water (for ceilings, use 1 part Acryl 60 to 2-1/2 parts of the water). This solution shall then be added to the Thoroseal plaster mix slowly in sufficient quantity so that the mixture is the consistency of a heavy batter suitable for application by method specified. Color to be selected by the Owner.

3. Application

At Contractor's option, one of the following methods of application shall be selected:

a. Sprayed-on finish should be applied with plaster-type spray gun, not high pressure paint type. Spray on evenly distributed coat of Thoroseal plaster mix. To spot-fill deep holes, float or brush first coat before starting second spray application.

Thoroseal plaster mix shall be applied on average surfaces in two coats at the rate of 5 to 6 lbs. per square yard for concrete walls, 6 to 9 lbs. per square yard for masonry walls; but sufficient material shall be applied to fill all holes and voids.

b. Trowel and float finish - Apply light trowel coat of Thoroseal plaster mix over entire surface to be treated. The workman shall make sure the material is firmly pressed into all voids and leveled. Allow this coat to cure thoroughly before applying the regular trowel application. When surface is set so it will not roll or lift, float uniformly using a sponge float.

Thoroseal plaster mix shall be applied on average surfaces at the rate of 4 to 6 lbs. per square yard for concrete walls, 6 to 9 lbs. for masonry walls. If concrete is rough or untrue, 6 to 9 lbs. per square yard may be required, but sufficient material shall be applied to fill and seal all pores and voids. This application will be approximately 1/8" thick. Leveling uneven surfaces will require more material per square yard.
To prevent shadowing of struck or deep masonry joints, or areas of unequal absorption (like some form marks), after key coat has cured for 5 days, apply a light trowel coat of Thoroseal plaster mix with Acryl 60 in the mixing water over the entire surface to be treated. Allow this coat to set thoroughly before applying the regular trowel application as outlined above.

Do not apply when temperatures are 40°F or due to fall below 40°F within 24 hours or to frozen or frost-filled surfaces.

3.9 CURING

A. General - Immediately following placing, all Class A and Class B concrete shall be protected from premature drying, hot and cold temperatures, rain, flowing water and mechanical injury. Maintain above 50°F and in moist condition for at least seven (7) days after placing for normal concrete and three (3) days for high early strength concrete. Comply with "Recommended Practice for Curing Concrete" ACI 308, unless otherwise indicated. Curing compound of satisfactory composition and characteristics may be used except on surfaces to which new concrete is to be bonded or surfaces scheduled to be painted or to receive other coating and provided such compound does not stain or discolor any surface which will be exposed. Cure formed concrete surfaces, including undersides of beams, supported slabs and other similar surfaces by moist curing with forms in place for full curing period or until forms are removed. If forms are removed, continue curing by methods specified above, as applicable.

B. Cold Weather Procedures - Protect concrete work from physical damage or reduced strength, which could be caused by frost, freezing actions, or low temperatures, in compliance with ACI 306, "Cold Weather Concreting", and as herein specified.

1. When air temperature has fallen to or is expected to fall below 40°F, uniformly heat water and aggregates before mixing as required to obtain a concrete mixture temperature of not less than 55°F, and not more than 80°F at point of placement.
2. Do not use frozen materials or materials containing ice, frost or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.

3. Do not use calcium chloride, salt and other materials containing antifreeze agents or chemical accelerators, unless otherwise accepted in mix designs.


C. Hot Weather Procedures:

When hot weather conditions exist that would seriously impair the quality and strength of concrete, place concrete in compliance with ACI 305, "Hot Weather Concreting", and as herein specified.

1. Cool ingredients before mixing to maintain concrete temperature at time of placement below 90°F. Mixing water may be chilled, or chopped ice may be used to control the concrete temperature provided the water equivalent of the ice is calculated to the total amount of mixing.

2. Cover reinforcing steel with water-soaked burlap if it becomes too hot, so that the steel temperature will not exceed the ambient air temperature immediately before embedment in concrete.

3. Wet forms thoroughly before placing concrete.

4. Do not use retarding admixtures unless otherwise accepted in mix designs.

5. Contractor shall obtain and keep on the project site a copy of ACI 305R, "Hot Weather Concreting" for reference during all concreting operations in hot weather.

D. Protection from the Sun:

All concrete shall be adequately protected from injurious action of sun in a manner satisfactory to the Engineer.
E. Temperature Control:

During and at the conclusion of the specified curing period, means shall be provided to ensure that the temperature of the air immediately adjacent to the concrete does not fall more than 3°F in any 1 hour nor more than 30°F in any 24 hours.

3.10 NON-SHRINKING GROUT

A. Where non-shrinking grout is called for on the Plan, it shall be mixed in strict accordance with the manufacturer's directions. It shall be of a type as recommended by the manufacturer for the particular application.

END OF SECTION
PART 1 – GENERAL

1.1 SCOPE

A. The extent of concrete reinforcement is shown on the drawings and in schedules.

B. The work includes fabrication and placement of reinforcement for cast-in-place concrete, including bars, welded wire fabric, ties and supports.

1.2 QUALITY ASSURANCE

A. Codes and Standards:

Comply with requirements of the latest edition of the following codes and standards, except as herein modified:

American Welding Society (AWS), AWS D1.4 "Recommended Practices for Welding Reinforcing Steel, Metal Inserts and Connections in Reinforced Concrete Construction".

Concrete Reinforcing Steel Institute (CRSI), "Manual of Standard Practice". (Current Ed.)

American Concrete Institute (ACI), ACI 318 "Building Code Requirements for Reinforced Concrete".

American Concrete Institute (ACI), ACI 350 “Code Requirements for Environmental Engineering Concrete Structures

B. Submittals:

Mill Certificates; Concrete Reinforcement: Submit steel producer's certificates of mill analysis, tensile and bend tests for reinforcing steel.

Shop Drawings: Reinforcing number, sizes, spacing dimensions, configurations, locations, mark numbers, lap splice lengths, concrete cover and reinforcing supports. Sufficient reinforcing details to permit installation of reinforcing without reference to contract drawings.
1.3 DELIVERY, HANDLING AND STORAGE

A. Deliver reinforcement to the project site bundled, tagged and marked. Use metal tags indicating bar size, lengths, and other information corresponding to markings shown on placement diagrams.

B. Store concrete reinforcement materials at the site to prevent damage and accumulation of dirt or excessive rust.

1.4 MATERIALS

A. Steel reinforcement shall conform to the "Specification for Deformed Billet Steel Bars for Concrete Reinforcement," ASTM A615, Grade 60.


C. Supports for Reinforcement shall be bolsters, chairs, spacers and other devices for spacing, supporting and fastening reinforcement in place. Use only wire bar type supports complying with CRSI recommendations, unless otherwise indicated. Do not use wood, brick, and other unacceptable materials.

1.5 SPLICES

A. No splices of bars, except when shown on the Plans, will be permitted without the approval of the Engineer. Minimum lap splice shall be 48 bar diameters unless specifically detailed or noted otherwise on drawings. Splices in adjacent bars shall be staggered a minimum distance equal to the lap splice length. Bars shall be rigidly clamped or wired at all splices in a manner approved by the Engineer. Welding may not be used except with the specific approval of the Engineer. Welding, when approved, shall conform to the AWS D1.4. Welded wire fabric shall be lap spliced a minimum of 2 inches plus the wire spacing at edge laps and end laps.

1.6 DETAILING & FABRICATION
A. Furnish Shop Detail and Field Placing Drawings for all reinforcing steel for approval of the Engineer. Shop Drawings shall include reinforcing, placing plans and details indicating size, location, arrangement, splice locations, bending diagrams, placing sequence, etc. Placing Drawings shall be in sufficient detail to allow field personnel to accurately place reinforcing. Shop and Placing Drawings shall be prepared in accordance with "Manual of Standard Practice for Detailing Reinforced Concrete Structures" ACI 315, current edition. Photographic copies of engineering drawings shall not be used as placing drawings.

B. Reinforcement bars shall be bent cold to the shapes indicated on the Plans. Fabrication tolerances, fabrication, and detailing of steel reinforcement shall conform to the "Manual of Standard Practice for Detailing Reinforced Concrete Structures" (ACI-315).

C. Steel reinforcement shall be of the type and size, cut to lengths and bent to shapes as indicated on the Plans. Unless otherwise indicated, hooks, lap splices, embedment lengths, and other details of reinforcement shall be provided as set forth in the ACI Building Code (ACI 318) to develop the full tensile strength of the bar.

1.7 PLACING REINFORCEMENT

A. All reinforcement at the time concrete is placed shall be free from mud, oil, paint, excessive rust and excessive mill scale or any other coating that would destroy or reduce its bond with the concrete.

B. All reinforcement shall be secured in place true to lines and grades indicated by use of metal or concrete supports, spacers, or ties as approved by the Engineer. The bars and mesh shall be tightly secured against displacement by ties of annealed wire, or suitable clips at intersections. Wall reinforcement shall be supported and held securely against displacement in its proper position clear of the forms as indicated on the Plans. Placing tolerance shall conform to ACI 318.

C. Nails shall not be driven into the wall forms to support reinforcement nor shall any other device used for this purpose come in contact with the form on the liquid side of any liquid containing structure. Metal devices used to provide the required clear distances from reinforcing steel to liquid side of concrete surfaces shall be galvanized, or shall be as approved by the Engineer.
D. The main reinforcement of slabs in contact with the ground shall be supported in its proper position, as indicated on the Plans, by means of precast cement mortar blocks, of approved dimensions, resting on the slabs' subbase. Such precast blocks shall be made of mortar composed of 1 part cement to 2 parts sand and shall have a loop of No. 16 black annealed wire cast into each block. The length of the wire loop shall be sufficient to allow the block to be tied to the reinforcement. Blocks shall be spaced at the intervals required to maintain the reinforcement in its required position in the slab during the placing of the concrete. The slab reinforcement shall not be used to support planking or runways used in placing concrete.

E. Bending of bars embedded in hardened concrete will not be permitted except when specifically approved by the Engineer for the field condition encountered. Field cutting of bars will only be permitted when specifically approved by the Engineer.

F. In the case of exposed finish surfaces of floor slabs, galleries, deck slabs, and beams, metal chairs, spacers and other metal accessories necessary to provide the required clear distances and proper alignment and spacing between bars shall be galvanized or shall have plastic protective covering over portions in contact with forms.

1.8 CONCRETE PROTECTION FOR REINFORCEMENT

A. Steel reinforcement shall be placed and held in position so that the concrete cover, as measured from the surface of the bar shall be the following, except as otherwise shown, on the drawings:

1. Slabs:

   1½ inches, in general, top and bottom.
   1½ inches at surfaces troweled as floor finish, walkway, or driveway.
   2 inches on bottom for slabs over water and where exposed to the weather.

2. Footings:

   2 inches at top of footings.
   3 inches at bottom, sides, and end of footings.
3. **Walls:**

   - 2 inches on surfaces against earth.
   - 1½ inches on interior surfaces.
   - 2 inches on interior surfaces contacting water.

4. **Beams and Girders in Contact with Water:**

   - 2 inch minimum to stirrup steel.
   - 2½ inch minimum to main longitudinal steel.

5. **Columns:**

   - 2 inches, in general, to main vertical reinforcement.
   - 2½ inches, to main reinforcement on surfaces in contact with water.

6. **Beams and Girders: General:**

   - 1½ inch minimum to stirrup steel.
   - 2 inches minimum to longitudinal steel.

END OF SECTION
PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Construction joints, expansion joints, and the placing of waterstops where such are indicated on the plans.

B. Construction joints shall be of the type indicated on the drawings and shall be located as shown on the plans unless otherwise approved by the Engineer. Contractor shall submit a joint location plan as specified in 204.8 CAST IN PLACE CONCRETE.

1.2 WATERSTOPS

A. Waterstops shall be installed in construction joints as required by the Plans. All waterstops shall be continuous throughout their length.

B. The waterstops shall be heavy duty polyvinyl waterstop conforming to Corps of Engineers Specification CRD-C-572, latest edition, as manufactured by Serviced Products Division of W.R. Grace and Company: Vinylstops by Sonneborn- Contech; Sealtight Duo-PVC Waterstops by W. R. Meadows, Inc.; Vinylex Corporation; "labyrinth" waterstop, Type B-2 as manufactured by Water Seals, Inc.; or an approved equal of the same type and material and approximately equal in dimensions and weight but not necessarily of exactly the same shape. Waterstops shall be of the size and type designated on the Plans.

C. "Rib Type" waterstops shall be of ribbed construction with a center bulb, 5" wide, capable of resisting a maximum pressure load of 65 feet of water.

D. All waterstops shall be installed so that one-half its width will be embedded on one side of the joint and one-half on the other. The Contractor shall employ a method of holding the waterstop in position for the first pour that is satisfactory to the Engineer. The method selected must insure that the waterstop will be held securely in true vertical or horizontal position and in straight alignment in the joint.

E. Care shall be exercised to insure that the waterstop is completely encompassed in good mortar.
F. Preformed Plastic Waterstops:

Preformed Plastic Waterstop, when approved by the Engineer, shall meet or exceed all requirements of Federal Specifications SS-S-00210, "Sealing Compound, Preformed Plastic for Expansion Joints", Type I or Type II. Such plastic waterstop shall be equal to SYNKO-FLEX as manufactured by Synko-Flex Products Company, Houston, Texas, or "CenSeal GS-231" by Concrete Sealants, Inc., New Carlisle, Ohio and shall meet the following requirements:

The plastic waterstop shall be produced from blends of refined hydrocarbon resins and plasticizing compounds reinforced with inert mineral filler, and shall contain no solvents, irritating fumes or obnoxious odors. The plastic waterstop shall not depend on oxidizing, evaporating or chemical action for its adhesive or cohesive strength. It shall be supplied in extruded form of suitable cross-section and of a size to seal the joint areas of concrete sections. The plastic waterstop shall be protected by a suitable removable two-piece wrapper. The two-piece wrapper shall be so designed that one-half may be removed longitudinally without disturbing the other half, to facilitate application of the sealing compound.

1.3 JOINTS IN WATERSTOPS

A. All waterstops shall be continuous and so joined at all points of contact in the same plane, or at intersections with waterstops in different planes, as to form a complete barrier to the passage of water through any construction or contraction joint.

B. Joints in the waterstops, whether made for the purpose of continuity in a straight strip or for the purpose of securing a watertight junction between strips in different planes, shall be made by heat welding as hereinafter specified.

C. Joints in PVC waterstops shall be made by heating the two surfaces to be jointed until the material has softened to the point where it is just short of being fluid and then bringing the two softened surfaces together with a slight rubbing motion followed by firmly pressing them together so that a solid and tight bond is made.
D. The joints in strips of waterstop made in the above manner shall be such that the entire cross section of the joint shall be dense, homogeneous and free of all porosity. All finished joints shall have a tensile strength of not less than 75 percent of the material of the strip as extruded.

E. The heating of the surfaces to be joined shall be done by means of an electric splicing iron designed for the specified purpose and controlled by means of a voltage regulator.

F. In use, the heat of the hot plate shall be so regulated as to prevent too rapid melting and accompanying charring of the waterstop material.

G. The use of makeshift hot plates will not be permitted nor will other means of heating the strips to be joined be allowed except in a case of emergency, as determined by the Engineer.

H. The Contractor shall provide such jigs as will assist in making the joints in a proper and workmanlike manner and in holding the strips so that the alignment of jointed strips is correct and angles are true to those required.

I. Prior to embedment all joints in the waterstop strips will be inspected by the Engineer and any found defective shall be remedied without delay.

1.4 PROTECTION OF WATERSTOP BETWEEN POURS

A. The Contractor shall take such steps as are necessary to protect exposed waterstops in the interim period between concrete pours. This would include damage from construction equipment, tools and concrete “slobbers”. In the event the waterstop receives small amounts of construction debris and/or concrete “slobbers” while concrete is “green”, the Contractor shall fully clean waterstop directly following the stripping of formwork and prior to the placement of future reinforcement.

1.5 EXPANSION JOINTS

A. Expansion joints of the size and type shown on the plans, or specified herein, shall be placed in concrete pavement or structure as shown on the plans.
1. Materials:

a. Preformed Asphalt Fiber Joint Material

Asphalt fiber sheet filler shall consist of preformed strips of inert material impregnated with asphalt. It shall be of the thickness shown on the Plans or indicated in these Specifications.

The sheet filler shall conform to the requirements of AASHTO Specification M-213 with the following additional provisions.

The sheet filler shall be of such character that it will not be deformed by ordinary handling during hot weather nor become hard and brittle in cold weather. It shall be of a tough, resilient, durable material not affected by weathering.

b. Hot Poured Rubberized Tar Joint Sealer

Hot poured rubberized mastic joint sealer shall consist of a mixture of durable, elastic rubber, coal tar pitch and other materials which will form a resilient and adhesive compound capable of effectively sealing concrete joint surfaces against repeated expansion and contraction. The material shall be installed in accordance with the manufacturer's directions. Hot poured tar sealer shall be used for pavement and sidewalk expansion joints.

B. Joint Surface Preparation:

1. Clean joint surfaces immediately before installation of sealant or caulking compound. Remove dirt, insecure coatings, moisture and other substances which would interfere with bond of sealant or caulking compound.

2. For all sealants, do not proceed with installation of sealant over joint surfaces which have been painted, lacquered, waterproofed or treated with water repellent
or other treatment or coating unless a laboratory test for durability (adhesion), in compliance with Paragraph 4.3.9 of FS TT-S-00227, has successfully demonstrated that sealant bond is not impaired by coating or treatment. If laboratory test has not been performed, or shows bond interference, remove coating or treatment from joint surfaces before installing sealant.

3. Etch concrete and masonry joint surfaces to remove excess alkalinity, unless sealant manufacturer's printed instructions indicate that alkalinity does not interfere with sealant bond and performance. Etch with 5% solution of muriatic acid; neutralize with diluted ammonia solution, rinse thoroughly with water and allow to dry before sealant installation.

C. Installation:

1. Comply with sealant manufacturer's printed instructions except where more stringent requirements are shown or specified and except where manufacturer's technical representative directs otherwise.

2. Prime or seal joint surfaces where shown or recommended by sealant manufacturer. Do not allow primer/sealer to spill or migrate onto adjoining surfaces.

3. Employ only proven installation techniques, which will insure that sealants will be deposited in uniform, continuous ribbons without gaps or air pockets, with complete "wetting" of joint bond surfaces equally on opposite sides. Except as otherwise indicated, fill sealant rabbet to a slightly concave surface, slightly below adjoining surfaces. Where horizontal joints are between a horizontal surface and a vertical surface, fill joint to form a slight cove, so that joint will not trap moisture and dirt.

4. Install sealants to depths as shown or, if not shown, as recommended by sealant manufacturer but within the following general limitations, measured at center (thin) section of bead.

5. For sidewalks, pavements and similar joints sealed with elastomeric sealants and
subject to traffic and other abrasion and indentation exposures, fill joints to a
depth equal to 75% of joint width, and neither more than 5/8" deep nor less than
3/8" deep.

6. For normal moving joints sealed with elastomeric sealants, but not subject to
traffic, fill joints to a depth equal to 50% of joint width, but neither more than ½"
deep nor less than 1/4" deep.

7. Do not allow sealants or compounds to overflow or spill onto adjoining surfaces,
or to migrate into voids of adjoining surfaces. Use masking tape or other
precautionary devices to prevent staining of adjoining surfaces, by either
primer/sealer or the sealant.

8. Remove excess and spillage of compounds promptly as the work progresses.
Clean adjoining surfaces by whatever means may be necessary to eliminate
evidence of spillage, without damage to adjoining surfaces or finishes.

9. Placement of expansion joint material shall fully cover joint area(s) between
concrete placements. No gaps or joint material opens which permit fresh
concrete to flow to existing concrete surface will be allowed.

D. Cure and Protection

1. Cure sealants in compliance with manufacturer's instructions and
recommendations, to obtain high early bond strength, internal cohesive strength
and surface durability. Do not cure in a manner which would significantly alter
material's modules of elasticity or other characteristics.

2. Installer shall advise Contractor of procedures required for curing and protection
of sealants during construction period, so that they will be without deterioration or
damage (other than normal wear and weathering) at time of Owner's acceptance.

END OF SECTION
PART 1 - GENERAL

1.1 SCOPE

A. Work in this section includes all labor, plant and material necessary to furnish and install all concrete formwork required by the project. Concrete formwork shall conform to all requirements of current editions of ACI 301 "Specifications for Structural Concrete for Buildings" and ACI 318 "Building Code Requirements for Reinforced Concrete" and ACI 347 "Recommended Practice for Concrete Formwork" and ACI 350 "Code Requirements for Environmental Engineering Structures" except as modified herein.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Forms shall be of wood, metal, highly water resistant plywood, or other material approved by the Engineer. Forms for sections greater than 18" thick shall be of wood. Form surfaces shall be smooth and free from irregularities, dents, sags, or holes when used for permanently exposed surfaces. Bolts and rods used for internal ties shall be so arranged that, when the forms are removed, all metal will not be less than two (2) inches from any concrete surface. Wire ties will not be permitted where concrete surface will be exposed to weathering, and discoloration would be objectionable. Exposed concrete shall have approved form liners of Masonite or plywood, or shall be constructed of smooth surfaced plywood.

B. Corner forms forming 3/4 inch chamfers or as otherwise specified on plans, shall be used on all outside corners that are to be exposed in the finished structure. Chamfer forms shall be of molded plastic or polyvinyl chloride chamfer strips. Use one style of form throughout the project. The type to be used shall be submitted to the Engineer for approval.

C. Rustication and Score Line Strips shall be a non-absorbent material such as extruded polyvinyl chloride, plastic, fiberglass or metal or they may be milled from a good quality lumber and well sealed to prevent moisture absorption, wood strips may not have protruding splinters which may become embedded in the concrete. Sealing wood shall be accomplished by emersion or brushing on two coats of form coating.
D. Form Ties for concrete shall have an approved waterstop barrier to prevent seepage of moisture along the ties. The ends of the metal after breaking off shall be minimum of 2 inches from the finished wall face. Submit samples to the Engineer for review. All temporary tie components of tie system shall be removed from placement once placement is completed and prior to backfilling. Non-shrink grout shall be placed at all voids created by ties.

E. Form Coatings: Provide commercial formulation form-coating compounds that will not bond with, stain, nor adversely affect concrete surfaces, and will not impair subsequent treatment of concrete surfaces requiring bond or adhesion, nor impede the wetting of surfaces to be cured with water or curing compounds.

F. Cylindrical Columns and Supports: Form round-section members with paper or fiber tubes, constructed of laminated plies using water-resistant type adhesive with wax-impregnated exterior for weather and moisture protection. Provide units with sufficient wall thickness to resist loads imposed by wet concrete without deformation.

G. Inserts: Provide metal inserts, anchor bolts and other embedded items for anchorage of materials or equipment to concrete construction, not supplied by other trades and as required for the work.

H. Provide sheet metal reglets formed of the same type and gauge as the flashing metal to be built into the reglets, unless otherwise indicated. Where resilient or elastomeric sheet flashing or bituminous membranes are terminated in reglets, provide reglets of not less than 26 gauge galvanized sheet steel. Fill reglet or cover face opening to prevent intrusion of concrete or debris.

I. Side forms of footings may be omitted and concrete placed directly against excavation only when requested by Contractor and accepted by Engineer. When forms are omitted, provide additional concrete required beyond the minimum design profiles and dimensions of the footings as indicated to provide minimum concrete coverage for reinforcement. Contractor shall maintain the earth form to proper alignment with no sloughing of material into the minimum design profile shown on the drawings.

J. Dovetail Anchor Slots at surfaces to receive masonry veneer to be Heckman #100 or equal.
K. Formwork used for exposed finished concrete surface placements shall be in like new condition and designed to provide flat and true surfaces.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Design and engineering of formwork, shoring and reshoring as well as its construction is the responsibility of the contractor. Design formwork for loads, lateral pressures and allowable stresses outlined in ACI 347R and for design considerations, wind loads, allowable stresses and other applicable requirements of the controlling local Building Code. Where conflicts occur between these two standards, the more stringent requirements shall govern.

B. Forms shall be built true to line and grade, and be mortartight and sufficiently rigid to prevent displacement or sagging between supports. All formwork and shoring shall be designed for the construction loads to be placed on them, and the design and construction of said forms shall be in accordance with ACI Standard “Recommended Practice for Concrete Formwork” (ACI 347). The structural adequacy of the formwork shall rest with the Contractor. All forms shall be so constructed that they can be removed without hammering or prying against the concrete.

C. Before concrete placement check the lines and levels of erected formwork. Make corrections and adjustments to ensure proper size and location of concrete members and stability of forming systems.

D. During concrete placement check formwork and related supports to ensure that forms are not displaced and that completed work will be within specified tolerances.

E. Provide temporary openings in wall forms, columns forms and at other locations necessary to permit inspection and clean-out.

3.2 EMBEDDED ITEMS

A. Before placing concrete, care shall be taken to determine that any embedded metal or wood parts are firmly and securely fastened in their correct location as indicated. Use setting drawings, diagrams, instruction and directions provided by suppliers of items
attached thereto. They shall be thoroughly clean and free from coating, rust, scale, oil, or any foreign matter. Embedding of wood in concrete shall be avoided whenever possible, metal being used instead. If wood is allowed, it shall be thoroughly wetted before concrete is placed.

B. All aluminum embedded items shall be coated with epoxy paint where in contact with concrete.

3.3 FORM REMOVAL

A. Forms shall not be removed without approval of the Engineer. Forms shall not be removed before the minimum times given below, or longer if job control tests indicate the concrete has not attained strength specified below, except when specifically authorized by the Engineer.

<table>
<thead>
<tr>
<th>Form Type</th>
<th>Minimum Removal Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beams and Slabs</td>
<td>14 days or proof of strength requirements met.</td>
</tr>
<tr>
<td>Walls up to 12&quot; Thick and</td>
<td>1 day if minimum daily temperature is above 50°F, 3 days otherwise</td>
</tr>
<tr>
<td>Vertical Surfaces</td>
<td></td>
</tr>
<tr>
<td>Columns</td>
<td>5 days or proof of strength requirements met.</td>
</tr>
<tr>
<td>Walls greater than 12&quot; Thick</td>
<td>3 days if minimum daily temperature is above 50°F with proof of strength requirements met, 7 days otherwise.</td>
</tr>
</tbody>
</table>

B. In general, forms or shores for supported slabs and beams shall not be removed until the concrete, so supported, has acquired 70% of its design strength; except where loads other than the dead weight of the concrete are added, the shores shall not be removed until 24 hours after the concrete has obtained 90% of its design strength. Forms shall be removed immediately after expiration of the lapsed times specified above or sooner, if required by the Engineer, where concrete is to receive a rubbed finish.

END OF SECTION
205 SUBMITTALS

All submittals shall be accompanied by a transmittal letter and/or cover letter that includes the project name and number, the contract specification number under which the equipment is being supplied, the Equipment ID number of the equipment being referenced, and the submittal revision number as appropriate.

205.1 Contractor shall submit, for each bid item, the manufacturer’s instructions and recommendations for installation, for subsequent testing of the units, and for ensuring they are in proper operation. These instructions shall be part of these specifications and binding on the contractor.

205.2 Contractor shall include, for each bid item, a work plan acceptable to the Engineer describing the duration and sequence of work. Plan shall be approved prior to commencement of work. All work requiring flow stoppage or removing equipment from service must be scheduled 48 hours in advance with Plant Superintendent. When flow stoppage is required for equipment installation, contractor shall have all necessary materials at the installation site prior to any flow stoppage, and shall proceed with installation of equipment to minimize downtime.

205.3 Contractor shall, within 15 days of issuance of Work Order, submit four (4) copies of the following items for review and approval - one (1) copy to be returned to Contractor following review, two (3) copies to be retained by Authority:

205.3.1 Product Data and Information: Submit catalog data including rating and descriptive literature of all components and systems for approval by Authority. This shall include items required by 204.

205.3.2 Itemized list with manufacturer’s part numbers, part descriptions and a schedule of values (unit prices) for the equipment proposed for each location.

205.3.3 Shop Drawings: Submit the following shop drawings for approval by Authority:

205.3.3.1 Bill of materials including manufacturers’ name and catalog number

205.3.3.2 Outline drawing showing dimensions, arrangement, and identification of components and nameplate schedule for all units

205.3.3.3 Individual schematic control diagrams for each unit.
205.3.4 Submittals should clearly identify items intended to be incorporated into the project. Mark or circle items clearly. Line through items or sizes that do not apply. Clearly identify where and what portion of the project the items are intended for use. Minimize “bundling” and separate important long lead time items out to coordinate and facilitate a review. Electrical and controls shall be submittal separately from related equipment.

205.3.4 Manufacturer’s start up, certifications and training requirements:

Manufacturer’s certification that the equipment is suitable and will perform within specification and manufacturer’s design operating parameters for the locations and conditions herein specified. Manufacturer’s services shall also include site visits by the Manufacturer’s Technical Representative’s prior to construction, during installation and for start-up, as necessary for an inspection, detailed start up report and Manufacturer’s certification of proper installation. Submit the Manufactures start-up report(s) and certification(s) of proper installation when they become available to the Engineer and during the week the equipment being put into service. Included final copies of the Manufacturer’s Start-up Certificates in the final O&Ms. Start-up report/Manufacture’s Certification should include pertinent start up details, equipment description, location, project information, complete initial set points, initial operational readings, equipment numbers and date and other pertinent system information for future operations and maintenance.

Training shall also be provided for the equipment and systems installed. Submit a draft training agenda, draft handouts, power point/video and a Manufacture’s Technical Representative’s resume for acceptance prior to scheduling the start-up and training. Provide two separate training days, as coordinated with the Plant to accommodate both day and night shifts. The duration of the training should be a minimum of 4 hours per training day of classroom and field training or more, if recommended by the Manufacturer. A professional video services shall also be provided to cover both complete class room and field training sessions. Deliverables are to Include; the full training video on DVD with the final
Provide additional standard manufacturer’s videos if available on the same DVD in the final O&M.

205.3.5 Safety Plan: This submittal will be checked for general conformance with Section 211 safety requirements and applicable OSHA and local regulations. Notwithstanding, it is the Contractor’s responsibility to ensure that the plan is comprehensive and in full conformance with all applicable OSHA, federal, state and local regulations.

205.3.6 Work Plan: Submit for approval by Authority, the work plan clearly showing the work task sequencing plan and time requirements, including downtime durations. This shall include items required by 204.

205.3.7 Submit for approval by Authority, plans and specifications for any concrete pad, support, piping, or other construction modifications from original installation.

205.3.8 Warrantee Equipment Log: Submit within 90 calendar days from the issuing of the Notice to Proceed, a Warrantee Equipment Log draft spreadsheet complete with project equipment information and equipment numbers for review. From that point on, the log will be updated each month by the Contractor and be a handout in the Monthly Meetings. Upon project completion, the spreadsheet shall be completed with all required information such as equipment numbers, start up dates, training dates, O&M dates and other relevant information and transmitted to the Owner for their future use in maintaining the equipment. A sample spreadsheet is available upon request. The warrantee log will be used as the tool to establish and agree on equipment warrantee period start date(s).

205.3.9 Schedule of values: Submit for approval by the Authority prior to and for the pay application process a proposal bid item based schedule of values with appropriate breakdowns. Contractor will be required to make appropriate and sufficient breakdown based on bid items, areas of work, scope, Subcontractor efforts and such relevant information that the pay application process can be reviewed more easily, as directed by the Authority.
205.4 Operations and Maintenance Manuals:

205.4.1 Contractor shall furnish to the Engineer two (2) hard copies and one soft searchable PDF of an preliminary Operation and Maintenance Manual complete for each piece of equipment and associated control systems furnished and installed.

205.4.2 Contractor shall furnish to the Engineer four (4) copies of all final O & M manuals on CDs/jump drives. CDs or jump drives shall be formatted in searchable pdf and shall contain all printed material included in the hard copies. A separate pdf folder shall be created for each Equipment numbered piece of equipment, within which all files pertaining to that piece of equipment shall be located.

205.4.3 Prior to the each area of work reaching 80 percent completion, Contractor shall submit to the Engineer for approval two (2) copies of the O&M manual with all specified materials and contents. Submittal of the approval copies shall be made with the partial payment request for the specified completion. Within 30 days after the Engineer’s approval of the two-copy submittal, Contractor shall furnish to the Engineer the remaining four (4) hard copies of the manual and the two searchable PDF copies on CD/jump drives. Contractor shall submit any missing material for the manual prior to requesting certification of substantial completion. On equipment with and requiring O&Ms, training and start-up, the last 10% of payment shall be for those items completed prior to applying for full payment of that item (100% payment).

205.4.4 Format and Contents: Each O & M manual shall include the following:

205.4.4.1 One copy of a completed EQUIPMENT NAMEPLATE AND SUMMARY DATA form.

205.4.4.2 One copy of the equipment Start-Up report and Manufacture’s certification of proper installation.

205.4.4.3 One copy of the manufacturer’s operating and maintenance instructions. Operating instructions include equipment start-up, normal operation, shutdown, emergency operation and troubleshooting. Maintenance instructions include equipment installation, calibration and adjustment, preventive and repair maintenance, troubleshooting, parts
list and recommended spare parts.

205.4.4.4 List of electrical relay settings and control and alarm contact settings.

205.4.4.5 Electrical interconnection wiring diagram for equipment furnished including all control and lighting systems.

205.4.4.6 Record drawings showing as-built schematic control diagrams for each unit and one-line diagrams.

205.4.4.7 Cross-references where required between the appropriate sections of the Contractor’s O&M manual and the manufacturers’ manuals.

205.4.4.8 The Contractor shall provide all required warrantee paperwork completed and filled in by the Contractor for the City’s use. The complete warrantee paperwork shall be specifically transmitted to the Plant Superintendent at time of start-up equipment being put into service and a separate copy be provided within the Final O&Ms also transmitted to the City.

205.5. Equipment Nameplate Information—Contractor shall, upon startup of each piece of equipment, complete the form, titled **EQUIPMENT NAMEPLATE AND SUMMARY DATA**, found at the end of this section, and shall include the completed form in the front of that equipment’s respective O & M manual. The form shall be included with each O & M manual copy submitted. Equipment ID nameplate requirements are found in specification section 204.3.6 of these specifications.

205.6 Submittals shall be sent to the following address:

Stephen Tolar, P.E.

Holloway, Updike and Bellen, Inc.

905-A South 9th Street.

Broken Arrow, OK 74012

(918) 251-0717

stolar@hubengineers.com
EQUIPMENT NAMEPLATE AND SUMMARY DATA

Equipment Number: _____________________________________________________________

Description (Include size): ______________________________________________________

Project #: ________________________________________________________________

Spec. #: ________________________________________________________________

Vendor: ___________________________________________________________________

Manufacturer: ______________________________________________________________

Model #: ________________________________________________________________

*Item or Drawing #: ______________________________________________________

*Serial #: ________________________________________________________________

Purchase Price: $ __________________________________________________________

Date Placed in Service (for 1-yr Warranty): _____________________________________

Manufacturer’s Warranty Period and End Date: __________________________________

Parts / Associated Details: ___________________________________________________

____________________________________________________________________________

____________________________________________________________________________

Maintenance Schedule

(May be an attached sheet from O&M Manual; do not use “See O&M Manual”)

✓ Initial: __________________________________________________________________

✓ Weekly: __________________________________________________________________

✓ Monthly: __________________________________________________________________

✓ Semi-Annual: __________________________________________________________________

✓ Annual: __________________________________________________________________

Applicable Motor Information: N.A. (Circle if not applicable)

Vendor: ___________________________________________________________________

Manufacturer: ______________________________________________________________

Model #: ________________________________________________________________

Item #: ________________________________________________________________

Serial #: ________________________________________________________________

Frame: __________________________ Insul. Class: __________________________

Volts/Hz/Amps: __________________________________________________________________

HP / RPM / SF: __________________________________________________________________

Manufacturer’s Warranty Period and End Date: __________________________________

*Item or Drawing # may not be unique. For example, it may be the same for a group of
same size valves or gates, each one having this same number that is unique to the
group. The Serial # should be listed only when unique to this individual piece of
equipment, otherwise it is N.A.
206 MONTHLY PROGRESS REPORTS AND PROGRESS MEETINGS

206.1 The Contractor shall submit monthly written project progress reports detailing the project’s progress to date, problems encountered or anticipated which impact project schedule, and plans for the next two weeks’ work.

206.2 Project progress reports shall be due as agreed upon during pre-work meeting.

206.3 Monthly progress meetings shall be scheduled on a weekday mutually agreeable to the Authority and the Contractor and shall be specified at the pre-work conference. The Contractor shall run the Monthly Meetings for the duration of the project and provide a meeting agenda including work completed, work planned, project, updated project schedule and other pertinent project status information.

206.4 The contractor shall submit a work progress and planned completion schedule for each bid item at the monthly progress meeting. The pre-work conference will constitute the first monthly progress meeting.

206.5 The Contractor shall maintain, update and submit an Equipment Log at each monthly meeting that lists each piece of equipment by Equipment ID number and lists Startup Date, Warranty Start Date and O&M Manual Submittal Date, among other project details. The spread sheet document shall be a shared document and submitted to the City at the end of the project for City’s future use. A sample Equipment log is available upon request.

207 SECURITY

207.1 Each project site where work is to be performed under this Contract is a secured site. The Contractor shall be responsible for security as described in this section.

207.2 Site Access: The Contractor shall respect all existing security measures at each project site, and shall implement the following measures to apply to all work performed under this Contract. Coordination for Plant access and City of Tulsa security pass access will be required.

207.2.1 Work at both Northside and Southside shall be restricted to the hours defined by TMUA GC-19 unless otherwise authorized by the Plant Superintendent.

207.3 Common Requirements

208.3.1 Identification Badges: An Identification Badge, issued by the City of Tulsa Security Office, is required for the following people:
· The driver of each vehicle that will be entering the facility multiple times or on a regular basis.

· Sub-contractors and foremen that will be supervising other workers.

The Identification Badge also functions as an Access Card to allow access through the front gate of the facility. One year is the maximum time that an Access Card is active.

208.3.2 Contractor will coordinate with the Engineer to request Identification Badges. Application for an Identification Badge will require a background investigation. Each person that is applying for an Identification Badge will need to complete the following two (2) forms:

· City of Tulsa Access Card / Identification Card Request Form

· City of Tulsa Security, Background and Prescreen Investigation Form

A current soft copy of the forms can be obtained from the Engineer.

208.3.3 The Contractor will send the completed forms as required. Approved individuals will coordinate with the City of Tulsa Security Office to complete the process and obtain their Identification Badge.

208.3.4 The Contractor will coordinate with the Engineer to request reactivation of Access Cards. Reactivation may require re-application and additional background investigation.

207.4 Contractor shall maintain a log book listing as a minimum the names of all persons admitted to each secured site by the Contractor, the purpose of the site visit, the dates and times of arrival at the site, entry to the secured site, and departure from the site.

207.5 Contractor and Authority acknowledge that Contractor shall not solely be responsible for all secured access to the site, that City personnel will have access and will be performing their regular duties pertaining to the operation and maintenance of the site facilities, and that security at the site shall require the cooperation of all persons authorized to access the site for the performance of their work. To the extent the Contractor is responsible for and has control of secured access, Contractor shall restrict site access to only persons essential to the performance or inspection of the work being performed under this Contract.
207.6 Contractor shall provide Engineer twenty-four (24) hours advance notification of any delivery of equipment or materials to the site, and shall make arrangements with Engineer to provide for inspection of such delivery.

207.7 Any observation by the Contractor of activity at or associated with the project site that Contractor observes and considers to be unusual or suspicious in nature, or that Contractor believes poses a threat to the integrity or welfare of the project site or associated facilities, shall be duly noted at the time of the observation in the log book identified in item B above. Any such observation shall be immediately reported to the Engineer.

207.8 No statement pertaining to security in these Specifications shall constitute a contract between Contractor and Authority for the performance of security services.

208 SAFETY

208.1 Contractor shall be responsible for performing all work under this contract in a safe manner and in compliance with all applicable local, state, and federal safety and health regulations. All of the following requirements shall apply:

208.2 Contractor shall submit a site safety plan prior to start of work. Contractor’s attention is directed to safety regulations applicable to the work under this contract, which include but are not limited to the following:

208.2.1 OSHA Standards 29CFR1910.147, the control of hazardous energy (Lockout/Tagout)

208.2.2 Fire Prevention and Protection: The Contractor shall take all necessary measures to prevent fire, and shall provide satisfactory firefighting means at the location of work.

208.2.3 Condition of Equipment and Materials: All equipment, tools, and appliances, and materials used in connection with the project shall be handled and operated only when they are in safe operating condition and in accordance with a standard safety procedure.

208.2.4 Confined Space Entry: Contractor shall determine if any work areas in this contract are considered permit spaces for entry, as defined in OSHA regulations, and shall perform all work so determined in accordance with all applicable state and federal labor, safety, and health regulations. The Contractor shall transmit with each pay application all the months copies of the Contractors confined space permits to the City and at the end of
the project with final pay application submittal a complete package of a copy of all the project’s Contactor confined space permits.

208.2.5 Combustible - Explosive Atmospheres: Contractor shall determine if any work areas in this contract are considered combustible and explosive spaces for entry, as defined in OSHA regulations, and shall perform all work and employ equipment in accordance with all applicable state and federal labor, safety, and health regulations.

209 PROTECTION OF PROPERTY

209.1 The protection of City, State and Government equipment, fences, gates, signs, and other City property is of prime importance, and if damaged, destroyed or removed, they shall be repaired, replaced, or paid for by the Contractor. Disturbance to this property must first be approved by the agency which controls it.

209.2 No valve or other control on any utility main or building service line shall be operated for any purpose by the Contractor.

209.3 At places where the Contractor’s operations are adjacent to, or crossing, the plane of railway, telegraph, telephone, electric, and gas lines, or water lines, sanitary sewers, and storm sewers, damage to which might result in expense, loss or inconvenience, work shall not be commenced until all arrangements necessary for the protection thereof have been made. Contractor shall notify the Notification Center of Oklahoma One-Call System, Inc., of any excavation or demolition prior to the commencement of such work. Notification shall be made no sooner than then (10) days nor later than forty-eight (48) hours prior to start of work, excluding Saturdays, Sundays, and legal holidays.

209.4 The Authority has attempted to locate all storm sewers, culverts, buried telephone or electrical conduits, sanitary sewers, water mains, and gas mains that might interfere with the construction of this project. The Contractor shall cooperate with the owners of any underground or overhead utility lines in their removal and rearrangement operations in order that these operations may progress in a reasonable manner and duplication or rearrangement work may be reduced to a minimum, and that services rendered by those parties will not be unnecessarily interrupted.

209.5 It shall be the responsibility of the contractor to follow all rules and regulations set forth by the Oklahoma Department of Environmental Quality with regards to storm water runoff associated with construction activities involving the disturbance of
The contractor shall review the regulations and determine if a DEQ storm water discharge permit is required. If a permit is required, it is the responsibility of the contractor to apply for and obtain the permit prior to disturbance of soil. If a permit is not required, the contractor shall still take all necessary action to comply with DEQ rules.

209.6 In the event the contractor in any way fails to comply with the requirement of protecting, repairing, and restoring of any utility or utility service, the Engineer may, upon forty-eight (48) hours’ notice, proceed to protect, repair, rebuild or otherwise restore such utility or utility service as may be deemed necessary, and the cost thereof will be deducted from any money due or which may become due the contractor pursuant to the terms of his contract.

210 PROTECTION OF MATERIALS

210.1 All materials and equipment delivered to the work site shall be adequately housed and protected against damage or deterioration as required by the equipment manufacturer. The Contractor shall keep his storage yard(s) in good order, arrange his materials neatly, and protect them from damage.

211 REFERENCES TO OTHER SPECIFICATIONS

211.1 Where a referenced American Society for Testing Materials (ASTM), National Electric Code (NEC), National Electrical Manufacturers Association (NEMA), American National Standards Institute (ANSI), Institute of Electrical and Electronics Engineers (IEEE), or other agency designated specification is specified for a material, component, or device, that designated specification shall be the current revision, either tentative or adopted. If a referenced specification is in disagreement with these specifications, the Tulsa Metropolitan Utility Authority specifications shall govern.

212 CLEAN-UP

212.1 Immediately upon completion of the work at each site in the contract, the Contractor shall remove all excess materials, equipment, tools, and debris, and restore the site to a condition and in a manner satisfactory to the Engineer.

213 PLACING WORK IN SERVICE

213.1 If desired by the Authority, portions of the work may be returned to service when completed, and the Contractor shall give prior access to the work for this purpose, but such use and operation shall not constitute an acceptance of the work. Any
such return to service shall comply with Section GC-38 of the General Conditions of these Contract Documents and Specifications.

213.2 **Warranty:** All equipment and work shall have a one (1) year factory warranty from date of acceptance, which shall include all materials and labor.

214 **PAYMENT**

214.1 Contractor shall submit a schedule of values for all major items of work as a basis for each partial payment. Payments will be made in accordance with section GC-29 of the General Conditions of these Contract Documents and Specifications. Contractor shall submit the SOV in sufficient time prior to the first pay application for the Engineer’s review. Contractor should anticipate a typical submittal review durations for the projects SOV review.

214.2 Contractor’s attention is directed to the Sales Tax Exemption Document in these Contract Documents and Specifications. Contractor shall have the option of instructing vendors to directly bill the Authority for materials the Contractor purchases while performing work under the terms of this Contract.

END OF SECTION