CONTRACT DOCUMENTS
AND
SPECIFICATIONS
FOR
PROJECT NO. ES 2018-01
NORTHSIDE LIFT STATION AND FORCEMAIN

ATTENDANCE AT PRE-BID CONFERENCE IS MANDATORY

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VOLUME II
TECHNICAL SPECIFICATIONS
FOR
NORTHSIDE LIFT STATION AND FORCemain
PROJECT NO. ES 2018-01

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Bruce Brown, P.E.
OK 20995

Brown Engineers of Arkansas, LLC.
C.A. No. 4933
Expires June 30, 2020
1.1 PROJECT TITLE:
Northside Lift Station and Force Main

1.2 PROJECT IDENTIFICATION:
Project No. ES 2018-01

1.3 OWNER:
Tulsa Metropolitan Utility Authority

1.4 PLANS AND SPECIFICATIONS PREPARED BY:
Stephen Tolar, P.E.
Holloway, Updike & Bellen, Inc.
905-A South 9th Street
Broken Arrow OK 74012
(918) 251-0717

1.5 MEASUREMENT AND PAYMENT:

It is the intent of the Proposal and these Special Conditions that the total bid, as submitted, shall cover all work shown on the contract drawings and required by the Specifications and other Contract Documents. All costs in connection with the work, including furnishing of all materials, equipment, supplies and appurtenances; providing all construction equipment and tools, and performing all necessary labor to fully complete the work, shall be included in the unit and lump sum prices named in the Proposal. No item of work that is required by the Contract Documents for the proper and successful completion of that contract will be paid for outside of or in addition to the prices submitted in the Proposal. All work not specially set forth in the Proposal as a pay item shall be considered a subsidiary obligation of the Contractor and all costs in connection therewith shall be included in the Lump Sum Prices named in the Proposal.

Payment cannot exceed 90% on any schedule of value item until items 1.13 Operation and Maintenance Manuals, item 1.15 Manufacture’s Startup/certification/Training Requirements and item 1.16 Miscellaneous Project Documentation with completed project’s equipment warrantee log have been completed and provided to the City as applicable. These last components as described in these sections of the contract’s work constitutes the last 10% of the cost of each item of the schedule of values as applicable.

1.6 ALLOWANCE:

An allowance has been provided in the contract for various mechanical, electrical, and plumbing (MEP) work.
A. The allowance shall be used for the cost of materials, labor, installation, and overhead and profit, in accordance with GC-26, for additional MEP work that is not identified in the Construction Documents / Plans, and not included in the base bid lump sum.

B. The allowance shall be used only at the discretion of the Authority.

C. The Contractor shall provide, to the Authority Representative, a written request for the use of the allowance, with a schedule of values, and associated backup information.

D. Contractor shall proceed with work included in the allowance only after receiving a written order, from the Authority Representative, authorizing such work. Proceeding with work in the allowance without a written order from the Authority Representative will be at the Contractor’s cost.

1.7 SCHEDULE OF VALUES:

The Contractor shall prepare a Schedule of Values for the work covered by the Agreement.

A. Generally, the Schedule of Values should reflect the format of the Proposal and include specified allowances, alternates and any alternate equipment selected by the Owner as applicable.

B. For Lump Sum items in the Schedule of Values should include breakdowns for major portions of the work including the following breakdown or as additionally required by the Engineer to facilitate the pay application process:

1. NORTHSIDE LIFT STATION AND FORCE MAIN EXPANSION:
   a. Excavation and Backfill for Lift Station Structure
   b. Structure Base Rock
   c. Structure Concrete
   d. Structure Misc. Metals
   e. Lift Station Equipment
   f. Building
   g. Bridge Crane
   h. Influent Vault
   i. Electrical and Controls

C. An unbalanced or front-end loaded schedule will not be acceptable.

D. Summation of the Complete Schedule of Values representing all Work shall equal the Contract Price.
E. The Schedule of Values shall be submitted to Engineer for approval prior to pay application processes and should be submitted during the week of the pre-construction meeting.

1.8 TRADE NAMES AND MATERIALS:

Where materials or equipment are specified by a trade or brand name, it is not the intention of the Owner to discriminate against an equal product of another manufacturer, but rather to set a definite standard of quality of performance, and to establish equal basis for the evaluation of bids. Where the words "Equivalent", "proper", or "equal to" are used, they shall be understood to mean that the thing referred to shall be proper, the equivalent of, or equal to some other thing, in the opinion or judgment of the Engineer. Unless otherwise specified, all materials shall be the best of their respective kinds and shall be in all cases fully equal to approved samples. Not withstanding that the words "or equal to" or other such expressions may be used in the Specification in connection with a material, manufactured article or process, the material, article or process, specifically designated shall be used, unless a substitute shall have been approved in writing by the Engineer and the Engineer shall have the right to require the use of such specifically designed material, article or process.

No material which has been used by the Contractor for any temporary purpose whatsoever is to be incorporated in the permanent structure without written consent of the Engineer.

1.9 COORDINATION:

A. Continuous operation of Owner’s facilities is of critical importance. Schedule and conduct activities to enable existing facilities to operate continuously, unless otherwise specified, and to minimize the number of shutdowns.

B. Perform Work continuously during critical connections and changeovers, as required, to prevent interruption of Owner’s operations.

C. Conduct Work outside regular working hours only with prior written consent of Owner.

D. Be responsible for planning, designing, and providing various temporary services, utilities, connections, temporary piping, bypass facilities and temporary connections, and similar items to maintain continuous operations of Owner’s facility. Sequences other than those specified will be considered upon written request to Owner and Engineer, provided they afford equivalent continuity of operations.
E. Do not close lines, open or close valves, or take other action which would affect the operations of existing systems, except as specifically required by the Contract Documents and after authorization by Owner and Engineer. Such authorization will be considered within 48 hours after receipt of Contractor’s written request.

F. Any tanks or pipelines requiring drainage prior to construction will be drained by the Owner’s staff to the maximum extent possible utilizing existing piping and drains where they exist. Contractor shall provide temporary pumping and effort to complete drainage of tank or pipeline as required. Provide minimum 7 days notice to Engineer and Owner of need to drain a facility, unless otherwise specified.

G. Power outages will be considered upon 48 hours written request to Owner and Engineer. Describe the reason, anticipated length of time, and areas affected by the outage in the written request. Provide temporary provisions for continuous power supply to critical existing facility components, as requested by Owner.

H. Coordinate proposed work with Engineer and Owner before implementing shutdowns. Under no circumstances shall Work end if such actions may inadvertently cause a cessation of any facility operation. In such cases, remain onsite until necessary repairs are complete and facility is brought back online.

1.10 STANDARD SPECIFICATIONS:

The City of Tulsa Public Works Department Standard Specifications and Standard Details October 2013 are hereby adopted as part of these Specifications where reference is made. Said Specifications will be referred to as the “Standard Specifications”.

The Oklahoma State Highway Commission "Standard Specifications for Highway Construction" latest edition are hereby adopted as part of these Specifications where reference is made. However, no portion of the Standard Specifications referring to Basis of Payment will be adopted as part of these Specifications.

1.11 CONTRACTOR’S FIELD OFFICE:

During the performance of this contract, the CONTRACTOR shall maintain a suitable office at or near the site of the work, which shall be headquarters of a representative authorized to receive drawings, instructions, maintain onsite up to date redline record drawings and other communication or articles. Any communication given to the said representative or delivered at the CONTRACTOR’s office at the site of the work in his absence shall be deemed to have been delivered to the CONTRACTOR.

Copies of the Drawings, SPECIFICATIONS, and other CONTRACT DOCUMENTS shall be kept at the CONTRACTOR’s office at the site of the work available for use at all times.

Contractor shall coordinate the location of the field office with the Plant Superintendent.
1.12 **ENGINEER’S FIELD OFFICE:**

For the use of the Engineer and other representatives of the Owner during the performance of this Contract, the Contractor shall provide and maintain at the site, at a location approved by the Engineer, a field office with a floor space of not less than 120 square feet and may be portable or other suitable type with 7-ft. minimum ceiling height. This office shall be of watertight construction with suitable windows and doors, properly screened, reasonably dustproof, electric lighting, heating, bath room and air conditioning, one desk minimum dimensions of 30” x 48”, one plan rack, two 4-drawer filing cabinets with locks and two chairs.

The field office shall be supplied with electric, water, sewer and High Speed Wireless Internet service.

In cold weather the building shall be provided with adequate vented space heating facilities and fuel for heating. In hot weather the building shall be equipped with adequate air conditioning units.

The Contractor shall carry insurance or otherwise be responsible for contents of the Engineer’s offices.

If all-weather parking surface is not readily available adjacent to the office, the Contractor shall provide and maintain a 4-inch crushed rock surfaced parking lot of sufficient size to park four full size cars with enough driveway area to provide unrestricted access to each parking space. At the completion of the project, the parking area shall be removed and the site returned to its original condition.

The field office shall remain the property of the Contractor and shall be removed by him upon the completion of Work.

1.13 **OPERATIONS AND MAINTENANCE MANUALS:**

Three (3) hard copies and Two (2) digital copies, unless otherwise stated, of manuals containing specifications, drawings and descriptions of each individual item of the equipment, equipment summary sheet, installation instructions, operating and maintenance instructions, inspection startup reports, initial set points if applicable, certifications and parts lists shall be provided. The manual shall be a single manual covering complete operating installation, separate sheets or brochures for the equipment not manufactured by the major supplier shall all be included. A cover pages and index shall also be included. These manuals shall be in addition to any instructions packed with the equipment and shall be submitted not later than the date of shipment of the equipment.

Preliminary O&Ms shall be submitted for review by the City and Engineer prior to equipment installation.
Final O&Ms shall be provided in 3-ring binder(s), 3” maximum, with clear view cover and spine, clearly identifying the project name/number and include index tabs if applicable, start up reports, certification, initial set points if applicable, City of Tulsa equipment summary sheet and Manufacture’s equipment O&M included. No spiral bound volumes permitted; spine must be suitable for affixing a self-adhesive label. All material content shall be clearly legible; material obscured or rendered partially illegible resolution as a result of photo-electronic reproduction will be considered unacceptable.

Digital copy shall be provided on CD or USB Drive of the complete final O&M. All files shall be formatted in current searchable Adobe PDF format.

O&Ms shall include a completed equipment summary data sheet (attached) for each equipment item that has been named/tagged/numbered on the drawings.

Final O&Ms shall include a “screen shot” PDF of each HMI screen updated and/or added by this contract into related equipment’s Final O&M. Contractor shall also transmit a complete package of PDF screen shots of each HMI screen updated and/or added by this contract as a summer booklet of HMI information and part of contract close out documentation.

Key project O&Ms shall be provided for:
   a. Pumps
   b. Grinder
   c. Crane/hoist
   d. Valves
   e. Gates
   f. Major electrical equipment.

Other appropriate equipment part of the project or requested by the Engineer. See other specification sections for additional requirements.

1.14 PROGRESS MEETINGS:

Monthly progress meetings shall be scheduled on a weekday mutually agreeable to the Authority, Engineer and the Contractor. A reoccurring date shall be agenda item in the pre-construction meeting (pre-work). The Contractor shall run the Monthly Meetings for the duration of the project and provide a meeting agenda including work completed, work planned, project updates, submittal/RFI logs, monthly updated project schedule, monthly updated warrantee log and other pertinent project status information.

The contractor shall submit a work progress and planned completion schedule for each bid item at the monthly progress meeting. The pre-construction (pre-work) conference will constitute the first monthly progress meeting, however the City will run the meeting. The Contractor, at the contractor’s option may include Subcontractor’s in the Monthly Progress Meeting as appropriate and helpful for coordination during construction.
MANUFACTURER’S START-UP, CERTIFICATIONS & TRAINING REQUIREMENTS:

Manufacture’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. Manufacture’s services shall also include site visits by the Manufacture’s Technical Representative’s prior to construction, during installation and for start-up, as necessary for an inspection, detailed start up report and Manufacture’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 Manufacture’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 Contractor may be required to provide additional training beyond specific equipment training where the equipment is part of a system. Multiple training events may be required for both the equipment components, control/integration and for the “system”. 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 O&Ms to the City. Provide additional standard Manufacturer’s videos if available on the same DVD in the final O&M.

Reference individual specification sections for additional information. Major components for training that should be included, but not limited to:

- Pumps
- Grinder
- Crane/hoist
- Major electrical equipment.
- See other specification sections for additional requirements.

MISCELLANEOUS PROJECT DOCUMENTATION:

Warrantee Equipment Log: Submit within 90 calendar days from the issuing of the Notice to Proceed, a draft Warrantee Equipment Log 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. A live spread sheet version shall be provided by the Contractor upon request by the
Authority. Upon project completion, the spread sheet shall be completed with all required information from the Contractor 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 spread sheet is available upon request from the Engineer. The warrantee log will be used as the project tool to establish and agree on equipment warrantee period start date(s). Equipment start up, City staff training completed and submission of draft O&Ms are the minimum requirements for a warrantee start date.

1.17 EXPLOSIVES:

The use of explosives will not be allowed.

1.18 INSPECTION:

The Contractor will provide access to the work site and facilities for representatives of the Environmental Protection Agency and Oklahoma Department of Environmental Quality and other agencies, as well as, Owner and Engineer, as required whenever the work is in progress.

1.19 SATURDAY, SUNDAY, HOLIDAY AND NIGHT WORK:

No work shall be done between the hours of 7:00 p.m. and 7:00 a.m., nor on Saturday, Sunday or legal holidays without the written approval or permission of the Owner, in each case, except such work as may be necessary for the proper care, maintenance and protection of work already done, or of equipment, or in the case of an emergency.

1.20 PROTECTION OF PROPERTY:

A. The protection of Local, State, and Government monuments, street signs and other Owner’s 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 which controls it.

B. No valves or other control on any utility main or building service line shall be operated for any purpose by the Contractor. Coordinate with Plant Operations for valve and other control on any utility main or building service line.

C. At places where the Contractor's operations are adjacent to the plant of railway, telegraph, telephone, electric and gas companies, or water, 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 completed.

D. 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 that services rendered by those parties will not be unnecessarily interrupted. The revision and crossings of the various types of lines shall be made as follows:

(1) Storm sewers and culverts may be removed at the time of crossing or may be adequately braced and held in position while the pipe is placed beneath them. If the storm sewer or culvert is removed, it shall be replaced with pipe of the same type and size as that removed and it shall be re-joined to the undisturbed line with a joint satisfactory to the Engineer. Backfill over the main up to and around the storm sewer shall be thoroughly compacted in order that no settlement will occur. The revision and crossing of said lines shall be at the expense of the Contractor.

(2) All overhead and buried telephone and electrical conduits, to be revised or crossed by the construction of this project shall be protected in accordance with the directions of the utility company owning the conduits and/or mains. The Contractor shall notify the companies and obtain their permission before making any crossing or revisions. The revision and crossing of said lines shall be at the expense of the Contractor. Any overhead cables or buried cables or conduits damaged by the Contractor shall be repaired at his expense to the satisfaction of the Engineer and of the Owner.

(3) The Contractor shall not remove any water or sanitary sewer lines except as directed by the Owner or as required by the Drawings and Specifications, and shall adequately brace and protect them from any damage during construction. Any existing water main or sewer main damage caused by the Contractor's operations will be repaired by the Contractor. The repairs will be made at the Contractor's expense.

E. The location of utility service lines serving individual properties are generally not shown on the Drawings, but the CONTRACTOR shall assume that such service lines exist whether or not they are shown on the Drawings, and it shall be the responsibility of the CONTRACTOR to contact the necessary utilities and have all utilities located. It shall be the responsibility of the CONTRACTOR to make any necessary changes in the line and/or grade of such services or to secure the necessary changes therein to be made by the particular utility company involved or other owner thereof, or by an agent or individual CONTRACTOR approved by such utility company or other owner. CONTRACTOR shall pay the cost of all such revisions whether performed by CONTRACTOR, the utility company or other owner, or an approved CONTRACTOR. In the event of interruption of a utility service as a result of accidental breakage, CONTRACTOR shall promptly notify the ENGINEER and the owner of the utility, and shall repair or cause the same to be repaired, in the same manner as necessary changes above are provided for, the CONTRACTOR shall do all things necessary to see that the restoration of
services are done as promptly as may be reasonably done.

F. In the event the Contractor in any way fails to comply with the requirements of protecting, repairing and restoring of any utility or utility service, the Owner may, upon forty-eight (48) hours written notice proceed to protect, repair, rebuild or otherwise restore such 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.

1.21 ASSISTANCE BY ENGINEER:

It is understood and agreed that such assistance as the Engineer may render to the Contractor in connection with the interpretation of drawings and Specifications shall not relieve the Contractor from any responsibility for the work. Any work which proves faulty shall be corrected by the Contractor without delay. The failure of the Engineer, or Resident Project Representative to call the Contractor's attention to faulty work or work performed which is not in accordance with Drawings and Specifications shall not imply acceptance or exempt the Contractor for correcting the improper work.

1.22 INCIDENTAL WORK:

Work called for on the Drawings and/or Specifications and are not set forth in the Bid Schedule as pay items, shall be considered as incidental work and will not be paid for directly, but shall be included in the price bid for the various pay items.

1.23 SUBSTANTIAL AND FINAL COMPLETION:

When the work is substantially complete, Contractor shall notify the Owner and Engineer in writing that the entire work is substantially complete (operational or beneficial occupancy) and request that Engineer issues a certificate of substantial completion. Work which may remain uncompleted at substantial completion shall include only minor surface work relative to right-of-way restoration, sodding, seeding, pavement replacement, etc.

Upon written notice from Contractor to the Engineer and Owner that the entire work is complete within the time called out on the Bid the Engineer will make a final inspection with Owner and Contractor and will notify Contractor in writing all particulars of the project which are incomplete or defective. Contractor shall immediately take such measures as are necessary to complete such work prior to final payment.

1.24 EXCAVATION:

No additional payment shall be made for encountering materials such as limestone, groundwater, or other natural formations.

Prior to any excavation work, Contractor shall contact OKIE (1-800-CALL-OKIE) as
well as all utility Owners within the work site.

1.25 **DETERMINATION AND EXTENSION OF CONTRACT TIME:**

The contract time consists of the number of calendar days stated in the Contract for the completion of the work beginning on the effective date of the work order or the date the CONTRACTOR begins work, whichever is earlier, including all Sundays, holidays and non-work days. All calendar days elapsing between effective dates of any orders of the Engineer to suspend work and to resume work for suspensions, not the fault of the CONTRACTOR shall be excluded.

The occurrence of unusually severe weather during the life of the contract will be considered a basis for extending contract time when work is not already suspended for other reasons. Unusually severe weather shall mean weather which at the time of year it occurs is unusual for the place in which it occurs.

Extension of time for unusually severe weather will be determined on a monthly basis and will include only those actual adverse weather days in excess of the normal adverse weather days included in the contract time. Normal adverse weather shall mean adverse weather which, regardless of its severity, is to be reasonably expected for that particular place at that particular time of year. The normal adverse weather days included in the contract time as shown in Table A are based on historical records of temperature and precipitation.

Actual adverse weather days are those days meeting one or more of the criteria in “a”, “b”, “c” and “d” below. Time extensions for days meeting more than one criterion will take into consideration only that criterion having the greatest impact. Those actual adverse weather days covered by criterion “a”, “b”, or “c” that are in excess of the days in Table A will be allowed without regard to when they occur (except prior to mobilization or during suspension for other reasons) or their impact on contract completion. However, those days covered by criterion “d” will be subject to the limitations as noted:

- **“a”** Days with Maximum temperature of 32º F or less - one full day allowed.
- **“b”** Days with Minimum temperature of 32º F or less, but whose Maximum temperature is over 32º F - one-half day allowed.
- **“c”** Days when 1/2” or more precipitation (rain or snow equivalent) occurs - one full day allowed.
- **“d”** Days when weather related conditions exist which prohibit proper performance of work as specified - one full day allowed. Allowance of such days will be subject to the work which is being delayed, being critical to timely contract completion and the CONTRACTOR making every reasonable effort to minimize the adverse impact of the conditions.
TABLE A
NORMAL ADVERSE WEATHER DAYS
(BY MONTH)

<table>
<thead>
<tr>
<th>MONTH</th>
<th>NORMAL ADVERSE WEATHER DAYS</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>9</td>
</tr>
<tr>
<td>February</td>
<td>7</td>
</tr>
<tr>
<td>March</td>
<td>6</td>
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<td>April</td>
<td>3</td>
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<td>May</td>
<td>3</td>
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<td>June</td>
<td>3</td>
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<td>July</td>
<td>2</td>
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<tr>
<td>August</td>
<td>2</td>
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<tr>
<td>September</td>
<td>3</td>
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<tr>
<td>October</td>
<td>3</td>
</tr>
<tr>
<td>November</td>
<td>5</td>
</tr>
<tr>
<td>December</td>
<td>7</td>
</tr>
</tbody>
</table>

END OF SECTION
1.1 **SCOPE.** This section covers delivery, storage, and handling of materials and equipment.

1.2 **DELIVERY.** Contractor shall bear the responsibility for delivery of equipment, spare parts, special tools, and materials to the site and shall comply with the requirements specified herein and shall provide required information concerning the shipment and delivery of the materials specified in this Contract. These requirements also apply to any sub-contractor suppliers making direct shipments to the Site.

Contractor shall, either directly or through contractual arrangements with others, accept responsibility for the safe handling and protection of the equipment and materials furnished under this Contract before and after receipt at the port of entry. Acceptance of the equipment shall be made after it is installed, tested, placed in operation and found to comply with all the specified requirements.

All items shall be checked against packing lists immediately on delivery to the site for damage and for shortages. Damage and shortages shall be remedied with the minimum of delay.

Delivery of portions of the equipment in several individual shipments shall be subject to review of Engineer before shipment. When permitted, all such partial shipments shall be plainly marked to identify, to permit easy accumulation, and to facilitate eventual installation.

1.3 **STORAGE.** Upon delivery, all equipment and materials shall immediately be stored and protected until installed in the Work.

Stacked items shall be suitably protected from damage by spacers or load distributing supports that are safely arranged. No metalwork (miscellaneous steel shapes and reinforcing steel) shall be stored directly on the ground. Masonry products shall be handled and stored in a manner to hold breakage, chipping, cracking, and spalling to a minimum. Cement, lime, and similar products shall be stored off the ground on pallets and shall be covered and kept completely dry at all times. Pipe, fittings, and valves may be stored out of doors, but must be placed on wooden blocking. PVC pipe, geomembranes, plastic liner, and other plastic materials shall be stored off the ground on pallets and protected from direct sunlight.

Pumps, motors, electrical equipment, and all equipment with antifriction or sleeve bearings shall be stored in weathertight structures maintained at a temperature above 60°F. Electrical equipment, controls, and insulation shall be protected against moisture and water damage. All space heaters furnished in equipment shall be connected and operated continuously.
Equipment having moving parts, such as gears, bearings, and seals, shall be stored fully lubricated with oil, grease, etc., unless otherwise instructed by the manufacturer. Manufacturer's storage instructions shall be carefully followed by Contractor.

When required by the equipment manufacturer, moving parts shall be rotated a minimum of twice a month to ensure proper lubrication and to avoid metal to metal "welding". Upon installation of the equipment, Contractor shall, at the discretion of Engineer, start the equipment at one-half load for an adequate period of time to ensure that the equipment does not deteriorate from lack of use.

When required by the equipment manufacturer, lubricants shall be changed upon completion of installation and as frequently as required thereafter during the period between installation and acceptance. New lubricants shall be put into the equipment by Contractor at the time of acceptance.

Equipment and materials shall not show any pitting, rust, decay, or other deleterious effects of storage when installed in the Work.

In addition to the protection specified for prolonged storage, the packaging of spare units and spare parts shall be for export packing and shall be suitable for long-term storage in a damp location. Each spare item shall be packed separately and shall be completely identified on the outside of the container.

1.4 HANDLING. Stored items shall be laid out to facilitate their retrieval for use in the Work. Care shall be taken when removing the equipment for use to ensure the precise piece of equipment is removed and that it is handled in a manner that does not damage the equipment.

END OF SECTION
PART 1 – GENERAL

1.1 SCOPE. This section covers the furnishing and installation of nameplates and tags for identification of equipment, valves, gates, panels, and instruments.

1.2 GENERAL. Except as otherwise specified in equipment, valve, and instrumentation sections, nameplates and tags shall be as specified herein. Nameplates or tags shall be provided for all equipment, valves, operator interfaces, control and electrical panels, cabinets, instruments, and instrument racks that have been named and/or tagged on the Drawings.

1.3 SUBMITTALS. Drawings and data shall be submitted in accordance with the requirements of the Submittals Procedures section for each type of tag provided including materials, colors, sizes, letter sizes, and installation instructions.

PART 2 - PRODUCTS

2.1 EQUIPMENT NUMBER PLATES. All Equipment tagged on the drawings, except for submerged equipment shall be provided with number plates bearing the equipment tag number and general description of item identified on the Drawings. The number plate and the description plate shall be two plates with number mounted one above the other as coordinated with the Engineer. Number plates shall be bevelled, 1/8th inch thick laminated blue phenolic plastic engraving stock with white core. Lettering on number plates shall be capitalized block letters ¾ inch high. Number plate height shall be twice the letter height. Number plate length shall be as needed, with suitable margins all around. Lettering shall be placed in one row where practicable; however, where necessary due to excessive length, lettering shall be placed on more than one row and centered.

Number plates shall be attached with stainless steel panhead screws, stainless steel rivets, or stainless steel drive screws.

When a number plate cannot be installed due to the physical size, space, other limitations or mounting surface geometry of the equipment, the Contractor shall provide a 12 gauge stainless steel tag with engraved or imprinted equipment tag number. Lettering on tags shall be ¼ inch high. Tags shall be rectangular with smooth edges, and shall be fastened to the equipment with stainless steel mechanical fasteners or with a stainless steel chain.

Additional tags showing the primary Equipment Number (ID number) and a secondary equipment description tag shall be provided for ancillary equipment that does not have an individual Equipment Number assigned. Ancillary equipment includes electrical control panels, power panels, transformers, disconnects, seal water stations, valves and other miscellaneous equipment as determined by the Owner.
2.2 VALVE AND GATE TAGS.

A. Temporary Tags. Each valve and gate with an identifying number indicated on the Drawings or listed in the valve or gate schedule, shall be tagged or marked in the factory with the identifying number.

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

Equipment Number Plates must follow the equipment numbering scheme.

Equipment Number Plates shall be attached with permanent ties.

All buried valves shall be tagged with a 304 stainless steel 1/32” plate with embed anchoring cast into a concrete collar pad at grade around valve box (See plans for detail). The numbers and service description shall be engraved in the plate with lettering and numerals at least 1 inch [25 mm] high.

Valve and gate tags shall at a minimum contain the following information:
“Descriptive System or Equipment Name”, as applicable
“Equipment Number”
“Plan ID (if different from Equipment Number)”

2.3 EQUIPMENT, PANELS, INSTRUMENTS.

A. Temporary Tags. Each equipment, panel or instrument with an identifying number indicated on the Drawings or listed in plan sheet schedule as applicable, shall be tagged or marked in the factory, by the factory with the identifying number and description tag.

B. Permanent Tags. All equipment tagged on the drawings, except for buried submerged equipment shall be provided with an Equipment Number Plate bearing the equipment tag number identified on the drawings. Equipment 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.

Example: 1st line XXXX -
          2nd line XXXX -
          3rd line XXXX -

Equipment Number Plates must follow the equipment numbering scheme.

Equipment Number Plates shall be attached with permanent adhesive.

Tags shall at a minimum contain the following information:
  “Descriptive System or Equipment Name”, as applicable
  “Equipment Number”
  “Plan ID (if different from Equipment Number)”

PART 3 – EXECUTION

Not used. See City of Tulsa standards and other specification sections as applicable.

END OF SECTION
**EQUIPMENT NAMEPLATE AND SUMMARY DATA**

<table>
<thead>
<tr>
<th>Equipment Number:</th>
<th>__________________________________________________________</th>
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</thead>
<tbody>
<tr>
<td>Description (Include size):</td>
<td>__________________________________________________________</td>
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<tr>
<td>Project #:</td>
<td>__________________________________________________________</td>
</tr>
<tr>
<td>Spec. #:</td>
<td>__________________________________________________________</td>
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<td>__________________________________________________________</td>
</tr>
<tr>
<td>Model #:</td>
<td>__________________________________________________________</td>
</tr>
<tr>
<td>*Item or Drawing #:</td>
<td>__________________________________________________________</td>
</tr>
<tr>
<td>*Serial #:</td>
<td>__________________________________________________________</td>
</tr>
<tr>
<td>Purchase Price:</td>
<td>$__________________________________________________________</td>
</tr>
<tr>
<td>Date Placed in Service (for 1-yr Warranty):</td>
<td>__________________________________________________________</td>
</tr>
<tr>
<td>Manufacturer’s Warranty Period and End Date:</td>
<td>__________________________________________________________</td>
</tr>
<tr>
<td>Parts / Associated Details:</td>
<td>__________________________________________________________</td>
</tr>
</tbody>
</table>

**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.
1. **SHOP DRAWINGS, SAMPLES AND PRODUCT DATA**

1.1 **GENERAL** - Submittals on component parts forming a system, or that are interrelated, shall be submitted at one time as a single submittal in order to demonstrate that the items have been properly coordinated and will function as a unit.

1.2 **Shop Drawings** - Identify details by reference to sheet and detail numbers shown on Contract Drawings. Use same symbols wherever practicable. Reproductions of Contract Drawings are acceptable as shop drawings only when specifically authorized in writing by the Engineer.

1.3 **Samples** - Includes all required physical examples to illustrate materials, equipment or workmanship, which establish standards by which completed work is urged. Must be of sufficient size and clarity, and in sufficient quantity to clearly illustrate functional characteristics and full range of colors, patterns, textures or other properties which will be actually produced.

1.4 **Product Data** - Includes manufacturer's schematic drawings, catalog sheets, brochures, diagrams, schedules, performance charts, illustrations, test reports, certificates of compliance, and other descriptive data not included on shop drawings. Modify standard descriptive data to delete information which is not applicable, and clearly identify pertinent data.

1.5 **SUBMISSION REQUIREMENTS** - Submittals shall be made with a letter of transmittal to the Engineer by the Contractor, and not by sub-contractors, suppliers or manufacturers.

1.6 Submit samples in number specified, or if not so specified, in triplicate.

1.7 Submit Project Data in sufficient quantity for required distribution and record, allowing two copies to be retained by Engineer.

1.8 Identify all submittals with the following information, as applicable:

- Project title and Engineer's project number.
- Name of Contractor, Engineer, originating sub-contractor or supplier.
- Submittal date, and all revision dates.
- Identify each product or material submittal by reference to Specification section and page no., drawing no., or any other contract document reference applicable thereto.

- Applicable conformance standards.
Include certification of Contractor review and conformity to contract requirements per General Conditions, Paragraph 6.25. Identify any deviations from Contract Documents. Provide 3" x 3" minimum space for Engineer's review stamp.

2. PROJECT RECORD DOCUMENTS

2.1 MAINTENANCE OF DOCUMENTS - Maintain at jobsite one record copy of Contract Drawings, Specifications, Addenda, approved Shop Drawings, Change Orders, other modifications to the Contract, field test records and other approved documents submitted by Contractor in compliance with Specification requirements.

2.2 Maintain documents at the project apart from documents used for construction. Do not use record documents for construction purposes. Maintain documents in clean, legible condition. Make documents available at all times for inspection of the Engineer and Owner.

2.3 RECORDING - Label each document "PROJECT RECORD COPY" in 2" high printed letters. Keep record documents current. Do not permanently conceal any work until required information has been recorded.

2.4 CONTRACT DRAWINGS - Legible mark most appropriate drawing to record, where applicable:

- Depths of various elements of foundation in relation to first floor level.
- Horizontal and vertical location of underground utilities and appurtenances referenced to permanent surface improvements.
- Location of internal utilities and appurtenances concealed in construction, referenced to visible and accessible features of structure.
- Field changes of dimension and detail made during construction process.
- Changes made by Change Order or Field Order.
- Details not on original Contract Drawings.
- Any change in location of facilities. Use City Survey Control System.

2.5 SPECIFICATIONS AND ADDENDA - Legibly mark up each Section to record:

- Manufacturer, trade name, catalog number, and supplier of each product and item of equipment actually installed.
- Changes made by Change Order or Field Order.
- Other matters not originally specified.

2.6 SHOP DRAWINGS - Maintain as record drawings. Legibly annotate shop drawings to record changes made after review. Use red felt tip marking pen for all recording.
2.7 **SUBMITTALS** - At completion of project, deliver record documents to the Engineer. Accompany submittal with transmittal letter, in duplicate, containing:

- Date, project title and number.
- Contractor's name and address.
- Title and number of each record document.
- Certification that each document as submitted is complete and accurate.
- Signature of Contractor or his authorized representative.

3. **PROJECT SUBMITTAL LOG**

3.1 Contractor shall provide draft submittal log prior to the first monthly meeting identifying and listing by specification number, description and other submittal information for use on the project. Contractor will incorporate comments provided by the Owners Representative. Log shall separately list the preliminary O&Ms also. Contractor shall maintain and provide a copy of the submittal log at each Monthly Progress Meeting.

END OF SECTION
PART 1- GENERAL

1.1 CLEARING AND GRUBBING

A. This item shall consist of the clearing and/or grubbing, including the disposal of materials for all areas within the construction limits of work reflected on the plans and any other areas designated on the plans.

B. Clearing shall consist of the removal of all trees, brush, stumps, logs, or other objects in the designated area(s).

C. Grubbing shall consist of the removal of all stumps, roots, buried logs, brush, grass, and other unsatisfactory materials to a depth of at least 18 inches unless the object if left would be detrimental to the purpose of the site in which case the object shall be totally removed to at least a depth which would not be detrimental to the purpose of the site.

D. Depressions left from the clearing and grubbing operations shall be filled using suitable fill material. The fill operation shall be done in six-inch (compacted thickness) lifts and compacted to 90% of maximum in future grass areas as determined by the Standard Proctor Test (ASTM D698) and to 95% of maximum in future pavement or structure areas as determined by the Standard Proctor Test (ASTM D698).

1.2 EXCAVATION AND EMBANKMENT

A. This item shall consist of the excavation, placement, compaction, and disposal of earth materials within the project area to the lines and grades shown on the plans. The contractor shall remove and dispose of excess excavation off site or provide borrow material from off site, both at his expense.

B. All excavation and embankment shall be unclassified with respect to pay purposes and shall be included in the lump sum contract price including any rock excavation.

C. Before beginning excavation, grading and embankment operations in any area, the area shall be completely cleared and/or grubbed.

D. The suitability of material to be placed in embankments shall be subject to approval by the Engineer. All unsuitable material shall be suitably disposed of by the Contractor. Waste areas shall be graded to allow positive drainage of the area and adjacent areas.

E. If it is necessary to interrupt existing surface drainage, sewers or under-drainage, conduits, utilities, or similar underground structures the Contractor shall be responsible for and shall take all necessary precautions to preserve them or provide temporary services. When such facilities are encountered, the Contractor
shall notify the Engineer, who shall arrange for their removal if necessary. The Contractor shall, at his/her own expense, satisfactorily repair or pay the cost of all damage to such facilities or structures which my result from any of the Contractor's operations during the period of the contract.

F. The contractor shall provide drains, pumps, well points or other equipment as necessary to dewater the site as required to perform the sitework.

G. All fill or embankment shall be placed in six-inch (compacted thickness) lifts and compacted, using suitable equipment to 95% of maximum as determined by the Standard Proctor Test (ASTM D698). Compliance with this requirement shall be evidenced by independent laboratory tests performed by and paid for by the Owner.

H. Rock in size or quantities such that a well compacted embankment cannot be assured will not be permitted in the fill material.

Stones or rocks in excess of four inches in their greatest dimension shall not be permitted in the top 24 inches of fill unless specifically required on the Construction Drawings. No rocks or debris larger than 6 inches in their greatest dimension shall be used as backfill.

I. Blasting will not be permitted

J. When an embankment is to be constructed on existing grade, all sod and vegetation shall first be removed and the cleared surface scarified to a depth of six inches and compacted to the same density as the fill to be placed.

K. The Contractor shall provide all necessary water and equipment to meet compaction requirements of fill material.

1.3 TOPSOIL

A. This item shall consist of the furnishing and placement of topsoil on embankments, excavations or areas directly or indirectly disturbed by the project work. If sufficient topsoil is not available on site the contractor shall obtain topsoil from offsite at no additional cost to the owner.

B. Topsoil shall be the surface layer of soil not less than 4” or if greater what is observed onsite with no admixture of refuse or material toxic or inhibitive to plant growth and shall be reasonably free of sub-soil, brush, roots, rocks, clay lumps, or similar objects.

The topsoil used from on site or otherwise furnished shall have a pH range of 5.5 to 7.6 when tested in accordance with the "Methods of Testing" of the Association of Official Agricultural Chemists. The organic content shall be not less than 3% nor more than 20% as determined by the Wet Combustion Method (chronic acid
reduction). There shall be not less than 20% nor more than 80% of the material passing the 200 mesh sieve as determined by the Wash Test in accordance with AASHTO T11.

C. Immediately prior to dumping and spreading topsoil, the surface shall be loosened by disc to a minimum depth of two inches. Prior to placing topsoil, the area shall be cleared of rocks in excess of 1½ inches in one dimension and any other debris or trash.

D. Topsoil shall be spread evenly on the prepared areas to a uniform depth of three inches after compaction.

   Spreading shall not be done when ground conditions are too wet or otherwise in a condition detrimental to the work.

   After spreading clods shall be broken up and rocks in excess of two inches, and any debris shall be removed.

   After spreading and debris removal is complete, the topsoil shall be compacted by rolling with a multi-packer.

1.4 SODDING

A. General:

   This item shall consist of sodding preparation, furnishing and placing sod in those areas topsoiled per section 1.3 these specifications and areas disturbed during construction activities. The use of seeding or vegetative mulch are not part of this project unless for the Contractors own temporary use(s).

B. Materials and Construction Methods:

   1. Sod shall be place in accordance with City of Tulsa Standard Specifications and Details, October 2013.

   2. Contractor shall coordinate and schedule final site fine grading and placement to promote grass growth. Full “carpet” grass growth of more than three inches shall be established during growing seasons.

   3. Spray for weeds and undesirables after grass is established.

   4. Sodding activity shall be shown on the Contractor project schedule.

   5. Fertilizer - Fertilizer shall be applied in liquid form at a concentration to provide the equivalent of a 10-20-10 commercial fertilizer applied at the rate of two hundred (200) pounds per acre, unless recommended otherwise by the Sod Supplier.

END OF SECTION
PART 1 - GENERAL

1.1 SCOPE

This section covers the demolition of existing piping, equipment and sitework and the salvage of existing material and equipment as indicated on the drawings.

1.2 GENERAL - Contractor shall be responsible for all work under this section.

All structures and facilities of the existing lift station which are not to be removed must remain in continuous operation during the proposed work. Demolition and salvage work shall create minimum interference with Owner's operations and minimum inconvenience to Owner.

Blasting will not be permitted.

PART 2 - PRODUCTS

Not Used

PART 3 - EXECUTION

3.1 DEMOLITION

A. Project Demolition

1. Refer to Construction Drawings for site demolition. Contractor is to protect the existing onsite structures, electrical, water and other services during demolition and the construction work. Refer to the Demolition Plan for demolition notes.

2. All miscellaneous metals shall be removed from structures and disposed of off site by the Contractor. This includes, grating, pipe supports, handrail, ladders, doors, door frames, window frames and other related items.

3. All surface and buried items associated the proposed structure and service shall be removed. This also includes sequenced demolition during construction and coordination for the removal of the gravity sanitary sewer piping at the new screening structure. Refer to the Demolition Plan and the Proposed Structural Plans for additional information.

B. Piping and Equipment Demolition – The following piping and equipment shall be removed and shall become the property of Contractor. All such items shall be promptly removed from the jobsite.
1. Existing valves and pump equipment not salvaged by the City and other related process and electrical equipment as shown on the Construction Drawings.

2. Excluding items identified in Demolition section 3.2 Salvage or shown on the Construction Drawings, demolition shall include pumps, piping, wire-conduits to extent possible, electrical cabinets, valves, equipment, related process items, electrical equipment and appurtenances being demolished.

3. Other underground piping as required to accomplish the proposed grading and proposed screening facilities as shown in the Construction Drawings.

C. Sitework Demolition shall include the following as indicated on the drawings:

1. Removal of concrete sidewalks, electrical duct, curbs, fencing, cable guards, trees-shrubs and other miscellaneous structures within the limits of the proposed grading as shown on the Construction Drawings.

3.2 SALVAGE

A. Items To Be Salvaged by Owner – Contractor shall coordinate with the Owners Representative to identify any Owner salvage items, if any. Contractor will be remove, packaged and delivered to Plant Maintenance Department. Larger items, like valves, fittings should be palletized and delivered to Plant Maintenance Department.

Items identified to be salvaged include at Owner option during construction:
   a. Pumps and appurtenances
   b. Valves and/or valve components
   c. Jib crane

B. Items To Be Salvaged by Contractor - Removed and salvaged equipment or facilities shall include removal and salvage of all accessories, piping, wiring, supports, associated electrical starters and devices, baseplates and frames, and all other appurtenances, unless otherwise directed.

1. Existing Materials and equipment removed, and not reused as a part of the work, shall become Contractor's property unless otherwise specified, and shall be removed from the jobsite.
2. Contractor may, at his option, furnish and install new items instead of those specified or indicated to be salvaged and reused, in which case such removed items will become Contractor's property.

END OF SECTION
A  DESCRIPTION OF WORK

This Section includes the following:

Preparation of subgrade for building slabs, foundations and structures.

Grading, excavation and fill for the site and structures shall be performed by the contractor to the grades indicated on drawings. The site plan shows approximate existing and proposed finish grades and elevations.

Undercut areas of subgrade that are spongy and yielding as designated by the engineer.

B  DEFINITIONS

1. Excavation consists of removal of material encountered to subgrade elevations indicated and subsequent disposal of materials removed.

2. Unauthorized excavation consists of removal of materials beyond indicated subgrade elevations or dimensions without specific direction of Engineer. Unauthorized excavation, as well as remedial work directed by Engineer shall be at Contractor's expense.

3. Additional Excavation: When excavation has reached required subgrade elevations, notify Engineer, who will make an inspection of conditions. If Engineer determines that bearing materials at required subgrade elevations are unsuitable, continue excavation until suitable bearing materials are encountered and replace excavated material as directed by Engineer.

4. Subgrade: The undisturbed earth or the compacted soil layer immediately below granular subbase, granular base, or topsoil materials.

5. Structure: Buildings, foundations, slabs, tanks, curbs, or other man-made stationary features occurring above or below ground surface.

C  SUBMITTALS

1. Product data for the following:

   Each type of plastic warning tape.

   Vapor barrier.
2. Samples of the following:

Coordinate, provide access to and provide equipment for selected samples(s) and/or deliver samples to City’s Independent Testing lab as required for new work. Submit Reports for products intended for backfill use.

3. Test reports: In addition to test reports required under field quality control, submit the following:

Laboratory analysis of each soil and base course material proposed for fill and backfill from on-site and borrow sources.

One optimum moisture-maximum density curve for each soil material.

Report of actual unconfined compressive strength and/or results of bearing tests of each stratum tested.

D QUALITY ASSURANCE

1. Codes and Standards: Perform excavation work in compliance with applicable requirements of authorities having jurisdiction.

2. Retesting of work: When initial testing indicates unacceptable work or materials, retesting will be paid for by the Contractor until acceptable results are achieved.

3. Codes and Regulations: All operations shall conform to applicable local and state codes and regulations including OSHA requirements.

E PROJECT CONDITIONS

1. Site Information: No geotechnical investigation has been performed.

2. Existing Utilities: It is the Contractor's responsibility to locate existing underground utilities in areas of excavation work prior to beginning the excavation. If utilities are indicated to remain in place, provide adequate means of support and protection during earthwork operations. The Contractor shall notify the appropriate utility for field location of all utilities.

3. Should uncharted, or incorrectly charted, piping or other utilities be encountered during excavation, consult utility owner immediately for directions. Cooperate with Owner and utility companies in keeping respective services and facilities in operation. Repair damaged utilities to satisfaction of utility owner.
4. Do not interrupt existing utilities serving facilities occupied by Owner or others, during occupied hours, except when permitted in writing by Engineer and then only after acceptable temporary utility services have been provided.

5. Provide minimum of 48-hour notice to Engineer, and receive written notice to proceed before interrupting any utility.

6. Demolish and completely remove from site existing underground utilities indicated to be removed. Coordinate with utility companies for shutoff of services if lines are active.

8. Protection of Persons and Property: Barricade open excavations occurring as part of this work and post with warning lights.

9. Operate warning lights as recommended by authorities having jurisdiction. Construction within street right-of-way may require an approved barricade and maintenance of traffic plan.

10. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earthwork operations.

11. Perform excavation by hand within dripline of large trees to remain. Protect root systems from damage or dryout to the greatest extent possible. Maintain moist condition for root system and cover exposed roots with moistened burlap.

F SOIL MATERIALS

1. It is acceptable to utilize the on-site soil materials for subgrade construction not indicated to be “backfill or fill” if the material can be successfully proof-rolled with a 20,000 pound pneumatic tired roller or loaded dump truck without excessive rutting or "pumping".

2. Granular Base Course: Washed, evenly graded mixture of crushed stone, or crushed or uncrushed gravel, with 100% passing a 3/4" sieve and not more than 5% passing a No. 4 sieve. Acceptable material will include coarse aggregate for concrete. Washed Concrete sand may also be used.

3. Backfill and Fill Materials: Soil materials having a liquid limit less than 45, a Plasticity Index (PI) between 8 and 20, free of rock or gravel larger than 2 inches in any dimension, debris, waste, frozen materials, vegetation, organics and other deleterious matter is designated “satisfactory” as determined by the Engineer and may be used for backfill and fill material.
4. Subbase Material: Soil material designated "satisfactory".

5. Vapor Barrier: 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.

G EXCAVATION

1. Excavation is unclassified and includes excavation to subgrade elevations indicated, regardless of character of materials and obstructions encountered.

2. Under footings, foundation bases, or retaining walls, fill unauthorized excavation by extending indicated bottom elevation of footing or base to excavation bottom, without altering required top elevation. Lean concrete fill may be used to bring elevations to proper position, when acceptable to Engineer.

3. Elsewhere, backfill and compact unauthorized excavations as specified for authorized excavations of same classification, unless otherwise directed by Engineer. If unsuitable bearing materials are encountered at required elevations, carry excavation deeper and replace excavated material as directed by Engineer.

4. Additional Excavation: When excavation has reached required subgrade elevations, notify Engineer who will make an inspection of conditions.

5. Stability of Excavations:
   a. Slope sides of excavations to comply with local codes, ordinances, and requirements of agencies having jurisdiction. Shore and brace where sloping is not possible because of space restrictions or stability of material excavated. Maintain sides and slopes of excavations in safe condition until completion of backfilling.
   b. Shoring and Bracing: Establish requirements for trench shoring and bracing to conform with local codes and authorities having jurisdiction. Provide materials for shoring and bracing, such as sheet piling, uprights, stringers, and cross braces, in good serviceable condition. Maintain shoring and bracing in excavations regardless of time period excavations will be open. Extend shoring and bracing as excavation progresses.

6. Trench and Excavation Safety Systems
   a. Description: This section covers trench and excavation safety system required for constructing improvements that necessitate open excavations on the project. All work under this item shall be in accordance with the
current edition of the "Occupational Safety and Health Administration Standard for Excavation and Trenches Safety System", 29 CFR 1926, Subpart P.

b. Notifications Required: The Contractor, prior to beginning any excavation, shall notify the State Department of Labor (Safety Division) that work is commencing on a project with excavations greater than five feet.

c. The Contractor shall notify all Utility Companies and Owners in accordance with OSHA Administration 29 CFR 1926.651(b) (2) for the purpose of locating utilities and underground installations.

d. Existing Structures and Utilities: Where the trench or excavation endangers the stability of a building, wall, street, highway, utilities or other installation, the Contractor shall provide support systems such as shoring, bracing, or underpinning to ensure the stability of such structure or utility. The Contractor may elect to remove and replace or relocate such structures or utilities with the written approval of the Owner of the structure of utility and the Project Owner.

H DEWATERING

1. Prevent surface water and subsurface or ground water from flowing into excavations and from flooding project site and surrounding area. No fill shall be placed in water or upon saturated soils.

2. Do not allow water to accumulate in excavations. Remove water to prevent softening of foundation bottoms, undercutting footings, and soil changes detrimental to stability of subgrades and foundations. Provide and maintain pumps, well points, sumps, suction and discharge lines, and other dewatering system components necessary to convey water away from excavations.

3. Establish and maintain temporary drainage ditches and other diversions outside excavation limits to convey rain water and water removed from excavations to collecting or runoff areas. Do not use trench excavations as temporary drainage ditches.

4. The Contractor is responsible for all surface runoff, ground water, rain or snow and system piping dewatering as necessary of the contract work.

I STORAGE OF EXCAVATED MATERIALS

1. Stockpile excavated materials satisfactory for backfill and fill where directed. Place, grade, and shape stockpiles for proper drainage.
2. Locate and retain soil materials away from edge of excavations. Do not store within drip line of trees indicated to remain.

3. Dispose of excess excavated soil material and materials not satisfactory for use as backfill or fill.

**J  EXCAVATION FOR STRUCTURES**

1. Conform to elevations and dimensions shown within a tolerance of plus or minus 0.10 foot, and extending a sufficient distance from footings and foundations to permit placing and removal of concrete formwork, installation of services, and other construction and for inspection.

2. Excavations for footings and foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before concrete reinforcement is placed. Trim bottoms to required lines and grades to leave solid base to receive other work.

**K  TRENCH EXCAVATION FOR PIPES AND CONDUIT**

1. Excavate trenches to uniform width, sufficiently wide to provide ample working room and a minimum of 6 to 9 inches of clearance on both sides of pipe or conduit.

2. Excavate trenches and conduit to depth indicated or required to establish indicated slope and invert elevations and to support bottom of pipe or conduit on undisturbed soil. Beyond building perimeter, excavate trenches to allow installation of top of pipe below frost line.

3. Where rock is encountered, carry excavation 6 inches below required elevation and backfill with a 6-inch layer of crushed stone or gravel prior to installation of pipe.

4. For pipes or conduit less than 6 inches in nominal size, and for flat-bottomed, multiple-duct conduit units, do not excavate beyond indicated depths. Hand-excavate bottom cut to accurate elevations and support pipe or conduit on undisturbed soil.

5. For pipes and equipment 6 inches or larger in nominal size, shape bottom of trench to fit bottom of pipe for 90 degrees (bottom 1/4 of the circumference). Fill depressions with tamped sand backfill. At each pipe joint, dig bell holes to relieve pipe bell of loads ensure continuous bearing of pipe barrel on bearing surface.

**L  BACKFILL AND FILL**
EXCAVATION & BACKFILL FOR BUILDINGS, STRUCTURES & UNDERFLOOR UTILITIES

1. General: Place satisfactory soil material in layers to required subgrade elevations, for each area classification listed below, using materials specified herein.

2. Under building slabs, provide satisfactory soils over an acceptable subbase material and provide a granular base immediately under slabs.

3. Under piping and conduit and equipment, use subbase materials where required over rock bearing surface and for correction of unauthorized excavation. Shape excavation bottom to fit bottom 90 degrees of cylinder.

4. Backfill trenches with concrete where trench excavations pass within 18 inches of column or wall footings and that are carried below bottom of such footings or that pass under wall footings. Place concrete to level of bottom of adjacent footing.

5. Backfill trenches for utility and piping as required for the area adjacent to the trench.

6. Do not backfill trenches until tests and inspections have been made and accepted. Use care in backfilling to avoid damage or displacement of pipe systems.

7. Backfill excavations as promptly as work permits, but not until completion of the following:
   a. Acceptance of construction below finish grade including, where applicable, dampproofing, waterproofing, and perimeter insulation.
   b. Inspection, testing, approval, and recording locations of underground utilities have been performed and recorded.
   d. Removal of shoring and bracing, and backfilling of voids with satisfactory materials.
   e. Removal of trash and debris from excavation.
   f. Permanent or temporary horizontal bracing is in place on horizontally supported walls.

M PLACEMENT AND COMPACTION

1. Ground Surface Preparation: Remove vegetation, debris, unsatisfactory soil materials, obstructions, and deleterious materials from ground surface prior to
placement of fills. Plow strip, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so that fill material will bond with existing surface.

2. Proof roll all existing soil areas under pavements, buildings and other structural site improvements with a 20,000 pound pneumatic tired roller or loaded dump truck. Areas which can be successfully proof rolled without excessive rutting or "pumping" are acceptable. Where proof rolling cannot be successfully accomplished, scarify and compact to stable condition. If stable condition cannot be achieved, notify Engineer.

3. Place backfill and fill materials in layers not more than 8 inches in loose depth for material compacted by heavy compaction equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers.

4. Before compaction, moisten or aerate each layer as necessary to provide optimum moisture content. Compact each layer to required percentage of maximum dry density or relative dry density for each area classification. Do not place backfill or fill material on surfaces that are muddy, frozen, or contain frost or ice.

5. Place backfill and fill materials evenly adjacent to structures, piping, or conduit to required elevations. Prevent wedging action of backfill against structures or displacement of piping or conduit by carrying material uniformly around structure, piping, or conduit to approximately same elevation in each lift.

6. Control soil and fill compaction, providing minimum percentage of density specified for each area classification indicated below. Correct improperly compacted areas or lifts as directed by Engineer if soil density tests indicate inadequate compaction.

   a. Under pavements, and exterior slabs compact the upper portion of the natural subgrade soils and fill material to not less than 95 % of maximum Standard Proctor dry density (ASTM D-698). Compact select fill layer to not less than 95% of maximum modified Proctor dry density (ASTM D-1557).

   b. Under structures and building areas, compact upper 8" of natural subgrade soils; fill and backfill materials (each layer) to 98 percent of maximum modified Proctor dry density (ASTM D-1557).

7. Moisture Control: Where subgrade or layer of soil material must be moisture conditioned before compaction, uniformly apply water to surface of subgrade or layer of soil material. Apply water in minimum quantity as necessary to prevent free water from appearing on surface during or subsequent to compaction operations.
8. Remove and replace, or scarify and air dry, soil material that is too wet to permit compaction to specified density.

N GRADING

1. General: Uniformly grade areas within limits of grading under this section, including adjacent transition areas. Smooth finished surface within specified tolerances, compact with uniform levels or slopes between points where elevations are indicated or between such points and existing grades.

2. Grading Outside Building Lines: Grade areas adjacent to building lines to drain away from structures and to prevent ponding.

3. Surface of fill under Building Slabs: Grade smooth and even, free of voids, compacted as specified, and to required elevation. Provide final grade within a tolerance of 1/2 inch when tested with a 10-foot straightedge.

4. Any excavation or grading under a building, structure or piping shall be backfilled with ODOT type A aggregate base rock and compacted to 98% standard proctor unless required contractually otherwise and is more stringent required. Rock backfill shall be extend at least two feet beyond structure “drip line” minimum.

O BUILDING SLAB BASE

1. General: Building slab base consists of placement of vapor barrier and granular base in layers of indicated thickness, over subgrade surface to support concrete building slabs.

2. Placing: Place granular base material on prepared subgrade in layers of uniform thickness, conforming to indicated cross-section and thickness. Compaction shall be by powered or hand tampers to 98% maximum density and then install vapor barrier.

P FIELD QUALITY CONTROL

1. Quality Control Testing During Construction: Allow testing service to inspect and approve each subgrade and fill layer before further backfill or construction work is performed.

2. If, in opinion of Engineer, based on testing service reports and inspection, subgrade or fills that have been placed are below specified density, additional compaction and testing shall be performed at the Contractor's expense until specified density is obtained.
EROSION CONTROL AND STORM WATER CONTROL

Provide erosion control and storm water runoff control methods in accordance with requirements of local and state authorities having jurisdiction.

MAINTENANCE

1. Protection of Graded Areas: Protect newly graded areas from traffic and erosion. Keep free of trash and debris.

2. Repair and reestablish grades in settled, eroded, and rutted areas to specified tolerances.

3. Reconditioning Compacted Areas: Where completed compacted areas are disturbed by subsequent construction operations or adverse weather, scarify surface, reshape, and compact to required density prior to further construction.

4. Settling: Where settling is measurable or observable at excavated areas during general project warranty period, remove surface (pavement, lawn, or other finish), add backfill material, compact, and replace surface treatment. Restore appearance, quality, and condition of surface or finish to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

DISPOSAL OF EXCESS AND WASTE MATERIALS

Remove trash, debris, and waste materials and dispose of it off Owner's property.

END OF SECTION
A. GENERAL REQUIREMENTS

1. Scope
   a. This specification addresses the implementation of temporary measures and devices to control erosion of soil from construction activities into waterways and drainage system.
   b. The contractor shall prepare a Stormwater Pollution Prevention Plan (SWP3), submit a Notice of Intent (NOI) to the Oklahoma Department of Environmental Quality (ODEQ), remit the necessary fee to ODEQ, and obtain written authorization to discharge stormwater from the ODEQ. Copies of the SWP3, NOI and authorization shall be submitted to the Engineer prior to the initiation of any construction activities.
   c. When a Stormwater Pollution Prevention Plan (SWP3) is prepared, the provisions of the SWP3, which resulted in the issuance of an authorization to discharge from ODEQ, shall govern.

B. PRODUCTS

1. Materials
   The following storm water pollution prevention control measures shall be installed where called for in the SWP3, as directed by the Engineer, or as conditions warrant.
   a. Silt Fence
      Silt fence shall consist of a geotextile fabric of either woven or non-woven polyester, polypropylene, stabilized nylon, polyethylene, or polyvinylidene chloride. The fabric shall be a minimum of 14 inches high and shall not exceed 28 inches in height measured from the installed ground elevation, and will have a minimum tensile strength of 120 pounds when tested according to ASTM D-4632.
   b. Erosion Control Mat
      Plastic erosion control mat shall consist of a loosely woven, flexible structure of nylon or vinyl monofilaments bonded into a three-dimensional mat. The mat will have a minimum thickness of 0.4 in. and a minimum tensile strength of 20 lb/ft when tested according to ASTM D-1682. The
mat materials shall be resistant to environmental, chemical and ultra-violet ray degradation. The mat shall be Enkamat 7010, or approved equal.

c. Straw Bales

Straw bales shall be standard rectangular size, approximately 18”x20”x36”, and shall be securely bound with wire.

d. Straw Mulch

The contractor shall install straw mulch as directed. Mulch shall be applied at the rate of 1½ tons per acre. Mulch shall be securely anchored in place.

C. EXECUTION

1. Installation

a. Silt Fence shall be constructed along the downstream side of the excavated area of the trench or stockpile material. It shall also be constructed at the top and/or toe of all slopes, where adjacent areas need protection from sediment laden run-off, or as directed by the engineer. Silt fences shall be supported by either steel or wood supports at intervals as specified by manufacturer’s installation practices. Silt fences shall be removed once the disturbed area is permanently stabilized and no longer susceptible to erosion.

b. All erosion control mats shall be installed according to the manufacturer’s specifications. The Contractor shall arrange for a manufacturer’s representative to be present during installation if requested by the Engineer.

1. The erosion control mat shall be rolled down from the top of the slope on top of the topsoil. The mat will be firmly staked in place with either 8-11 gauge steel wire U-staples or wood stakes. The steel staples shall be driven a minimum of 8 in. into the ground and shall be left flush with the top of the mat. If wood stakes are used, they shall be driven a minimum of 12 in. into the ground and left no more than 1 in. above the mat surface.

2. Mats shall be overlapped a minimum of 3 in. on the sides and 12 in. when joining one roll with another. The uphill roll shall always be left on top when joining two rolls on a slope. Stakes shall be
placed at 3-ft 5-in. intervals along the side overlaps of each roll. Two stakes shall be placed in each joint with another roll.

3. A minimum of 1 in. of topsoil mixed with seed will be placed on the installed mat and worked into the voids of the mat.

4. Topsoil need not be placed under the fabric/grout type erosion control map.

c. Rows of straw bales shall be placed at 500 foot intervals on relatively flat grades and 200 foot intervals on grades over 5% along the downstream side of the excavated area of the trench or stockpile material. Bales shall be firmly anchored with wood or metal stakes approximately 3 feet long. A sediment sump shall be placed immediately upstream of each bale. Contractor shall clean and maintain sediment sumps throughout the maintenance period. Straw bales shall be removed once the disturbed area is permanently stabilized

2. Stabilization

The following stabilization practices and structural practices will be incorporated as short and long term goals in providing proper controls to minimize and/or eliminate storm water pollution to the receiving waters.

a. Temporary Stabilization

Topsoil stockpiles and disturbed portions of the site where construction activity temporarily ceases for at least 21 days will be stabilized with temporary seed and mulch no later than 14 days from the last construction activity in that area. The temporary seeding shall be Rye (grain) applied at the rate of 120 pounds per acre. Prior to seeding, 870 pounds of 10-20-10 fertilizer shall be applied to each acre stabilized. After seeding, each area shall be mulched with 4,000 pounds per acre of straw. The straw mulch is to be tacked into place by a disk with blades set nearly straight.

b. Permanent Stabilization

Disturbed portions of the site where construction activities permanently cease shall be stabilized as directed by plans and specifications no later than 14 days after the last construction activity.
3. Controls

a. Storm Water Management

The storm water drainage shall not be impacted by construction activities. All disturbed areas which are not paved (street, sidewalk or parking) shall be regarded to match existing grades and have permanent sodding or mulch seeding.

b. Waste Materials

All waste materials shall be collected and stored in a securely lidded metal dumpster rented from a licensed solid waste management company. The dumpster will meet all local and any state solid waste management regulations. All trash and construction debris from the site shall be deposited in the dumpster. The dumpster shall be emptied in a minimum of twice per week or more if necessary, and the trash shall be hauled to an approved landfill. No construction materials shall be buried onsite. The contractor’s onsite representative (the individual who manages the day to day operations) shall be responsible for seeing that these practices are followed.

c. Hazardous Waste

All hazardous waste materials shall be disposed of in a manner specified by local or state regulation or by the manufacturer. Site personnel shall be instructed in these practices and the contractor’s onsite representative shall be responsible for seeing that these practices are followed.

d. Sanitary Waste

All sanitary waste shall be collected from the portable units a minimum of three times per week by a licensed sanitary waste management contractor, as required by local regulation.

e. Offsite Vehicle Tracking

Pavement adjacent to any activity shall be swept daily to remove any excess mud, dirt, or rock tracked from the construction site. Dump trucks hauling material from the construction site shall be covered with a tarpaulin.
f. Site Discharges

Only storm water and non-storm water discharges associated with construction activities will be permitted. Non-storm discharges shall include pavement wash-waters (where no spills or leaks of toxic or hazardous material have occurred) and uncontaminated groundwater (from dewatering excavation). No other industrial activity discharges will be permitted.

4. Maintenance/Inspection and Control Procedures

The following are the inspection and maintenance practices that will be used to maintain erosion and sediment controls.

a. Inspection

All control measures will be inspected at least once each week and following any storm event of 0.5 inches or greater.

b. Maintenance

All measures shall be maintained in good working order, if a repair is necessary, it will be initiated within 24 hours of report.

c. Sediment Removal

Built up sediment will be removed from the silt fence and straw bales when it has reached one-third the height of the structure.

d. Straw Bales

Straw bales will be inspected for deterioration, washout, movement, and sediment depth. Deteriorated bales will be removed and replaced as needed.

e. Silt Fence

Silt fence will be inspected for depth of sediment, tears, and proper installation to see if the fabric is securely attached to the fence posts and wires, and to see that the fence posts are firmly anchored in the ground.
f. Seeding

Temporary seeding will be inspected for bare spots, washouts, and healthy growth.

g. Inspectors

The contractor’s on-site representative will select three individuals who will be responsible for inspections, maintenance and repair activities.

h. Training

Personnel selected for inspection and maintenance responsibilities will be trained in all necessary maintenance practices necessary for keeping the erosion and sediment controls used onsite in good working order.

5. Material Management Practices

The following are the practices that will be used to reduce the risk of spills or other accidental exposure of material and substances to storm water runoff during the construction project.

a. Storage

The following requirements shall be met for the storage of products used during the work.

1. An effort will be made to store only enough product required to do the job.

2. All materials stored onsite will be stored in a neat, orderly manner in their appropriate containers and, if possible, under a roof or other enclosure.

3. Products will be kept in their original containers with the manufacturer’s label.

b. Mixing Substances

Substances will not be mixed with others unless recommended by the manufacturer.
c. Disposal

The following requirements shall be met relative to the disposal of products used during the work.

1. Whenever possible, all of the product will be used before disposing of the container.

2. Manufacturer’s or local and state recommended methods and sites for disposal will be followed if surplus product must be disposed of.

d. Inspection

The contractor’s on-site representative will inspect daily to ensure proper use and disposal of materials on site.

e. Hazardous Materials

Products will be kept in original containers unless they are not re-sealable.

1. Original labels and material safety data will be retained.

2. If surplus product must be disposed of, manufacturer’s or local and state recommended methods and sites for proper disposal will be followed.

6. Product Specific Practice

The following product specific practices will be followed onsite.

a. Petroleum Products

All onsite vehicles will be monitored for leaks and receive regular preventative maintenance to reduce the chance of leakage. Petroleum products will be stored in tightly concealed containers which are clearly labeled. Any asphalt substances used onsite will be applied accordingly to the manufacturer’s directions.

b. Fertilizers

Fertilizers used will be applied only in the minimum amounts recommended by the manufacturer. Once applied, fertilizers will be
worked into the topsoil to limit exposure to storm water. Storage will be in a covered shed. The contents of any partially used bags of fertilizer will be transferred to a sealable plastic bin to avoid spills.

c. Paints/Epoxies

All containers will be tightly sealed and stored when not required for use. Excess paint or epoxies will not be discharged to the storm sewer system but will be properly disposed of according to manufacturer’s instructions or state and local regulations.

End of Section
A. GENERAL

This work shall cover the composition, mixing, construction upon the prepared subgrade, and the protection of hot asphalt concrete pavement. The hot asphalt concrete pavement shall consist of an aggregate or asphalt base course and asphalt surface course constructed in conformity with the lines, grades, thickness, and cross sections as shown. Each course shall be constructed to the depth, section, or elevation required by the drawings and shall be rolled, finished, and approved before the placement of the next course.

1. Inspection of plant and equipment

The Engineer shall have access at all times to all parts of the material producing plants for checking the mixing operations and materials and the adequacy of the equipment in use.

2. Alignment and grade control

The contractor’s land surveyor shall establish and control the pavement (aggregate or asphalt base course and asphalt surface course) alignments, grades, elevations, and cross sections as shown on the drawings.

3. Submittals

a. Data and Test Reports:

1. Aggregate Base Course: Sources, gradation, liquid limit, plasticity index, percentage of wear, and other tests required by State Highway Department.

2. Asphalt Base/Surface Course: Aggregate source, gradation, soundness loss, percentage of wear, and other tests required by State Highway Department.


b. Certifications:

1. Asphalt prime and tack coat material certificate of conformance to State Highway Department requirements.

2. Asphalt cement certificate of conformance to State Highway Department requirements.
3. Job-mix certification - Submit plant mix certification that mix equals or exceeds the State Highway Specification.

c. One copy of State Highway Department Specifications.

d. Provide MSDS (Material Safety Data Sheets) for all chemicals used on ground.

B. PRODUCTS

1. Aggregate base and asphalt concrete materials shall conform to the requirements of the following and other appropriate sections of the latest version of the state highway material specifications, including amendments, addenda and errata. Where the term "engineer" is referenced in the state highway specifications, it shall mean the project engineer.

2. Aggregates

a. Provide aggregates consisting of crushed stone, gravel, sand, or other sound, durable mineral materials processed and blended, and naturally combined.

b. Subbase aggregate (where required) maximum size: (1-1/2").

c. Base aggregate maximum size:

1. Base course over (6") thick: (1-1/2");

2. Other base courses: (3/4").

d. Asphaltic base course:

1. Maximum particle size not to exceed (1").

2. Where conflicts arise between this specification and the requirements in the latest version of the State Highway Specifications, the State Specifications shall control.

e. Aggregates for asphaltic concrete paving: Provide a mixture of sand, mineral aggregate, and liquid asphalt mixed in such proportions that the percentage by weight will be within:
Sieve Sizes | Percentage Passing
--- | ---
(3/4") | 100
(3/8") | 67 to 85
(1/4") | 50 to 65
(No. 8 mesh) | 37 to 50
(No. 30 mesh) | 15 to 25
(No. 200 mesh) | 3 to 8

plus 50/60 penetration liquid asphalt at 5 percent to 6-1/2 percent of the combined dry aggregates.

3. Asphalts
   a. Comply with provisions of Asphalt Institute Specification SS2:
      1. Asphalt cement: Penetration grade 50/60
      2. Prime coat: Cut-back type, grade MC-250
      3. Tack coat: Uniformly emulsified, grade SS-1H

4. Sealer
   a. Provide a sealer consisting of suitable fibrated chemical type asphalt base binders and fillers having a container consistency suitable for troweling after thorough stirring, and containing no clay or other deleterious substance.
   b. Where conflicts arise between this specification and the requirements in the latest version of the State Highway Specifications, the State Specifications shall control.

C. EXECUTION

The Asphalt Concrete Paving equipment, weather limitations, job-mix formula, mixing, construction methods, compaction, finishing, tolerance, and protection shall conform to the requirements of the appropriate sections of the State Highway Specifications for the type of material specified.

1. Mixing Asphaltic Concrete Materials
      1. Temperature leaving the plant: 143 degrees C(290 degrees F) minimum, 160 degrees C(320 degrees F) maximum.
2. Temperature at time of placing: 138 degrees C (280 degrees F) minimum.

2. Subgrade

a. Shape to line and grade and compact with self-propelled rollers.

b. All depressions that develop under rolling shall be filled with acceptable material and the area re-rolled.

c. Soft areas shall be removed and filled with acceptable materials and the area re-rolled.

d. Should the subgrade become rutted or displaced prior to the placing of the subbase, it shall be reworked to bring to line and grade.

e. Proof-roll the subgrade with maximum (50 ton) gross weight dump truck as directed by Engineer. If pumping, pushing, or other movement is observed, rework the area to provide a stable and compacted subgrade.

3. Base Courses

a. Subbase (when required)

1. Spread and compact to the thickness shown on the drawings.

2. Rolling shall begin at the sides and continue toward the center and shall continue until there is no movement ahead of the roller.

3. After completion of the subbase rolling there shall be no hauling over the subbase other than the delivery of material for the top course.

b. Base

1. Spread and compact to the thickness shown on the drawings.

2. Rolling shall begin at the sides and continue toward the center and shall continue until there is no movement ahead of the roller.

3. After completion of the base rolling there shall be no hauling over the base other than the delivery of material for the top course.

c. Thickness tolerance: Provide the compacted thicknesses shown on the Drawings within a tolerance of minus (0.0") to plus (0.5").
d. Smoothness tolerance: Provide the lines and grades shown on the Drawings within a tolerance of (3/16 inch in ten feet).

e. Moisture content: Use only the amount of moisture needed to achieve the specified compaction.

4. Placement Of Asphaltic Concrete Paving

a. Remove all loose materials from the compacted base.

b. Apply the specified prime coat, and tack coat where required, and allow to dry in accordance with the manufacturer’s recommendations as approved by the Engineer.

c. Receipt of asphaltic concrete materials:

1. Do not accept material unless it is covered with a tarpaulin until unloaded, and unless the material has a temperature of not less than 130 degrees C (280 degrees F).

2. Do not commence placement of asphaltic concrete materials when the atmospheric temperature is below 10 degrees C (50 degrees F), not during fog, rain, or other unsuitable conditions.

d. Spreading:

1. Spread material in a manner that requires the least handling.

2. Where thickness of finished paving will be (3") or less, spread in one layer.

e. Rolling:

1. After the material has been spread to the proper depth, roll until the surface is hard, smooth, unyielding, and true to the thickness and elevations shown own the drawings.

2. Roll in at least two directions until no roller marks are visible.

3. Finished paving smoothness tolerance:

   a. No depressions which will retain standing water.

   b. No deviation greater than (1/8" in six feet).
5. **Application Of Seal Coat**

   a. Prepare the surfaces, mix the seal coat material, and apply in accordance with the manufacturer’s recommendations as approved by the Engineer.

   b. Apply one coat of the specified sealer.

   c. Achieve a finished surface seal which, when dry and thoroughly set, is smooth, tough, resilient, of uniform black color, and free from coarse textured areas, lap marks, ridges, and other surface irregularities.

6. **Protection**

   Protect the asphaltic concrete paved areas from traffic until the sealer is set and cured and does not pick up under foot or wheeled traffic.

7. **Testing**

   The Owner shall engage an independent testing laboratory to conduct onsite tests. Contractor will be responsible for assisting in sampling for test at the field directed by the Owners Representative. The Contractor shall be responsible for the costs of work performed by the laboratory required for any retesting or rework resulting in materials placed determined to be unacceptable by the Owner. Additional requirements are defined by City standards as applicable.

   At least one test shall be made per placement day (or fraction thereof) placed on any one day and in any event, not less than one test for each type of material utilized that day. One test per 50 tons of materials placed. Additional tests beyond requirements may be pulled at the sole discretion of the Owners Representative.

8. **Final Clean-Up**

   Remove all debris, rubbish, and excess material from the work area.

**END OF SECTION**
A. GENERAL REQUIREMENTS

1. Scope

   a. This specification addresses the implementation of temporary measures and devices to control erosion of soil from construction activities into waterways and drainage system.

   b. The contractor shall prepare a Stormwater Pollution Prevention Plan (SWP3), submit a Notice of Intent (NOI) to the Oklahoma Department of Environmental Quality (ODEQ), remit the necessary fee to ODEQ, and obtain written authorization to discharge stormwater from the ODEQ. Copies of the SWP3, NOI and authorization shall be submitted to the Engineer prior to the initiation of any construction activities.

   c. When a Stormwater Pollution Prevention Plan (SWP3) is prepared, the provisions of the SWP3, which resulted in the issuance of an authorization to discharge from ODEQ, shall govern.

B. PRODUCTS

1. Materials

   The following storm water pollution prevention control measures shall be installed where called for in the SWP3, as directed by the Engineer, or as conditions warrant.

   a. Silt Fence

      Silt fence shall consist of a geotextile fabric of either woven or non-woven polyester, polypropylene, stabilized nylon, polyethylene, or polyvinylidene chloride. The fabric shall be a minimum of 14 inches high and shall not exceed 28 inches in height measured from the installed ground elevation, and will have a minimum tensile strength of 120 pounds when tested according to ASTM D-4632.

   b. Erosion Control Mat

      Plastic erosion control mat shall consist of a loosely woven, flexible structure of nylon or vinyl monofilaments bonded into a three-dimensional mat. The mat will have a minimum thickness of 0.4 in. and a minimum tensile strength of 20 lb/ft when tested according to ASTM D-1682.
mat materials shall be resistant to environmental, chemical and ultra-violet ray degradation. The mat shall be Enkamat 7010, or approved equal.

c. Straw Bales

Straw bales shall be standard rectangular size, approximately 18”x20”x36”, and shall be securely bound with wire.

d. Straw Mulch

The contractor shall install straw mulch as directed. Mulch shall be applied at the rate of 1½ tons per acre. Mulch shall be securely anchored in place.

C. EXECUTION

1. Installation

a. Silt Fence shall be constructed along the downstream side of the excavated area of the trench or stockpile material. It shall also be constructed at the top and/or toe of all slopes, where adjacent areas need protection from sediment laden run-off, or as directed by the engineer. Silt fences shall be supported by either steel or wood supports at intervals as specified by manufacturer’s installation practices. Silt fences shall be removed once the disturbed area is permanently stabilized and no longer susceptible to erosion.

b. All erosion control mats shall be installed according to the manufacturer’s specifications. The Contractor shall arrange for a manufacturer’s representative to be present during installation if requested by the Engineer.

1. The erosion control mat shall be rolled down from the top of the slope on top of the topsoil. The mat will be firmly staked in place with either 8-11 gauge steel wire U-staples or wood stakes. The steel staples shall be driven a minimum of 8 in. into the ground and shall be left flush with the top of the mat. If wood stakes are used, they shall be driven a minimum of 12 in. into the ground and left no more than 1 in. above the mat surface.

2. Mats shall be overlapped a minimum of 3 in. on the sides and 12 in. when joining one roll with another. The uphill roll shall always be left on top when joining two rolls on a slope. Stakes shall be
placed at 3-ft 5-in. intervals along the side overlaps of each roll. Two stakes shall be placed in each joint with another roll.

3. A minimum of 1 in. of topsoil mixed with seed will be placed on the installed mat and worked into the voids of the mat.

4. Topsoil need not be placed under the fabric/grout type erosion control map.

c. Rows of straw bales shall be placed at 500 foot intervals on relatively flat grades and 200 foot intervals on grades over 5% along the downstream side of the excavated area of the trench or stockpile material. Bales shall be firmly anchored with wood or metal stakes approximately 3 feet long. A sediment sump shall be placed immediately upstream of each bale. Contractor shall clean and maintain sediment sumps throughout the maintenance period. Straw bales shall be removed once the disturbed area is permanently stabilized

2. Stabilization

The following stabilization practices and structural practices will be incorporated as short and long term goals in providing proper controls to minimize and/or eliminate storm water pollution to the receiving waters.

a. Temporary Stabilization

Topsoil stockpiles and disturbed portions of the site where construction activity temporarily ceases for at least 21 days will be stabilized with temporary seed and mulch no later than 14 days from the last construction activity in that area. The temporary seeding shall be Rye (grain) applied at the rate of 120 pounds per acre. Prior to seeding, 870 pounds of 10-20-10 fertilizer shall be applied to each acre stabilized. After seeding, each area shall be mulched with 4,000 pounds per acre of straw. The straw mulch is to be tacked into place by a disk with blades set nearly straight.

b. Permanent Stabilization

Disturbed portions of the site where construction activities permanently cease shall be stabilized as directed by plans and specifications no later than 14 days after the last construction activity.
3. Controls

a. Storm Water Management

The storm water drainage shall not be impacted by construction activities. All disturbed areas which are not paved (street, sidewalk or parking) shall be regarded to match existing grades and have permanent sodding or mulch seeding.

b. Waste Materials

All waste materials shall be collected and stored in a securely lidded metal dumpster rented from a licensed solid waste management company. The dumpster will meet all local and any state solid waste management regulations. All trash and construction debris from the site shall be deposited in the dumpster. The dumpster shall be emptied in a minimum of twice per week or more if necessary, and the trash shall be hauled to an approved landfill. No construction materials shall be buried onsite. The contractor’s onsite representative (the individual who manages the day to day operations) shall be responsible for seeing that these practices are followed.

c. Hazardous Waste

All hazardous waste materials shall be disposed of in a manner specified by local or state regulation or by the manufacturer. Site personnel shall be instructed in these practices and the contractor’s onsite representative shall be responsible for seeing that these practices are followed.

d. Sanitary Waste

All sanitary waste shall be collected from the portable units a minimum of three times per week by a licensed sanitary waste management contractor, as required by local regulation.

e. Offsite Vehicle Tracking

Pavement adjacent to any activity shall be swept daily to remove any excess mud, dirt, or rock tracked from the construction site. Dump trucks hauling material from the construction site shall be covered with a tarpaulin.
f. Site Discharges

Only storm water and non-storm water discharges associated with construction activities will be permitted. Non-storm discharges shall include pavement wash-waters (where no spills or leaks of toxic or hazardous material have occurred) and uncontaminated groundwater (from dewatering excavation). No other industrial activity discharges will be permitted.

4. Maintenance/Inspection and Control Procedures

The following are the inspection and maintenance practices that will be used to maintain erosion and sediment controls.

a. Inspection

All control measures will be inspected at least once each week and following any storm event of 0.5 inches or greater.

b. Maintenance

All measures shall be maintained in good working order, if a repair is necessary, it will be initiated within 24 hours of report.

c. Sediment Removal

Built up sediment will be removed from the silt fence and straw bales when it has reached one-third the height of the structure.

d. Straw Bales

Straw bales will be inspected for deterioration, washout, movement, and sediment depth. Deteriorated bales will be removed and replaced as needed.

e. Silt Fence

Silt fence will be inspected for depth of sediment, tears, and proper installment to see if the fabric is securely attached to the fence posts and wires, and to see that the fence posts are firmly anchored in the ground.
f. Seeding

Temporary seeding will be inspected for bare spots, washouts, and healthy growth.

g. Inspectors

The contractor’s on-site representative will select three individuals who will be responsible for inspections, maintenance and repair activities.

h. Training

Personnel selected for inspection and maintenance responsibilities will be trained in all necessary maintenance practices necessary for keeping the erosion and sediment controls used onsite in good working order.

5. Material Management Practices

The following are the practices that will be used to reduce the risk of spills or other accidental exposure of material and substances to storm water runoff during the construction project.

a. Storage

The following requirements shall be met for the storage of products used during the work.

1. An effort will be made to store only enough product required to do the job.

2. All materials stored onsite will be stored in a neat, orderly manner in their appropriate containers and, if possible, under a roof or other enclosure.

3. Products will be kept in their original containers with the manufacturer’s label.

b. Mixing Substances

Substances will not be mixed with others unless recommended by the manufacturer.
c. Disposal

The following requirements shall be met relative to the disposal of products used during the work.

1. Whenever possible, all of the product will be used before disposing of the container.

2. Manufacturer’s or local and state recommended methods and sites for disposal will be followed if surplus product must be disposed of.

d. Inspection

The contractor’s on-site representative will inspect daily to ensure proper use and disposal of materials on site.

e. Hazardous Materials

Products will be kept in original containers unless they are not re-sealable.

1. Original labels and material safety data will be retained.

2. If surplus product must be disposed of, manufacturer’s or local and state recommended methods and sites for proper disposal will be followed.

6. Product Specific Practice

The following product specific practices will be followed onsite.

a. Petroleum Products

All onsite vehicles will be monitored for leaks and receive regular preventative maintenance to reduce the chance of leakage. Petroleum products will be stored in tightly concealed containers which are clearly labeled. Any asphalt substances used onsite will be applied accordingly to the manufacturer’s directions.

b. Fertilizers

Fertilizers used will be applied only in the minimum amounts recommended by the manufacturer. Once applied, fertilizers will be
worked into the topsoil to limit exposure to storm water. Storage will be in a covered shed. The contents of any partially used bags of fertilizer will be transferred to a sealable plastic bin to avoid spills.

c. Paints/Epoxies

All containers will be tightly sealed and stored when not required for use. Excess paint or epoxies will not be discharged to the storm sewer system but will be properly disposed of according to manufacturer’s instructions or state and local regulations.

End of Section
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>
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</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.
CAST-IN-PLACE CONCRETE

3.1 - 6

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
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 40ºF, uniformly heat water and aggregates before mixing as required to obtain a concrete mixture temperature of not less than 55ºF, and not more than 80ºF 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 90ºF. 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 insure 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.

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1.9. ADDITIONAL REINFORCEMENT

A. The Contractor shall provide on the job site additional reinforcement to be used at locations as directed by the Engineer at no additional cost to the Owner. The contract price shall include all labor and material charges for handling, field cutting and bending, bar supports, and placing of said reinforcement. Additional reinforcement shall be ASTM A615, Grade 60 and is beyond reinforcement indicated on the contract drawings. Field bending will be limited to right angle bends and standard 90 degree hooks on No. 3 & No. 4 Bar sizes. Additional steel shall be as follows:

No. 3 bars - 20 pieces 20'-0" long
No. 4 bars - 30 pieces 20'-0" long
No. 5 bars - 30 pieces 20'-0" long
No. 6 bars - 20 pieces 20'-0" long

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 SECTION 3.1 - 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: Vinylstoppers 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>Category</th>
<th>Minimum Removal Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beams and Slabs</td>
<td>14 days or proof of strength met.</td>
</tr>
<tr>
<td>Walls up to 12&quot; Thick</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</td>
</tr>
</tbody>
</table>
requirements met, 7 days otherwise.

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
A. **SCOPE**

This section covers the furnishing and installation of all miscellaneous metals, including stainless steel, cast iron, and aluminum items not covered in other sections of the Specifications. Work generally included but is not limited to ladders, gratings, handrails and railings, anchorage devices, metal fabrications, and metal stairs.

B. **GENERAL**

Furnish all miscellaneous items such as anchor bolts, tie down bolts, nuts and washers, supports, connections, expansion and toggle bolts, etc., required by the work. Supplementary parts necessary to complete each item, though such work is not definitely shown or specified, shall be included. Furnish to appropriate trades all anchors, sockets or fastenings required for securing metal work to other constructions and wood items to concrete. Details and specifications of items for which standard products are available are representative guides of requirements for such items. Standard products generally meeting such requirements, will be accepted. Welding shall be continuous along entire area of contact, except where tack welding is permitted. Tack welding will not be permitted on exposed surfaces. All exposed welds shall be ground smooth. Riveting, where exposed, shall be flush type.

C. **QUALITY ASSURANCE**

Take field measurements prior to preparation of shop drawings and fabrication, where possible. Do not delay job progress; allow for trimming and fitting wherever taking field measurements before fabrication might delay work.

Preassemble items in shop to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation.

D. **SUBMITTALS**

Submit for Engineer's review, 4 sets of shop drawings for fabrication and erection of miscellaneous metal items. Include plans, elevations, and details of sections and connections. Show anchorage and accessory items. Provide templates for anchor and bolt installation by others. Submit duplicate samples of all prefinished or shop finished items for approval of finishes. See specification section 1.3 for additional requirements.

E. **MATERIALS AND COMPONENTS**

1. **Metal Surface, General:** For fabrication of miscellaneous metal work which will be exposed to view, use only materials which are smooth and free of surface
blemishes including pitting, seam marks, roller marks, rolled trade names and roughness.

2. Ferrous Metals: Except as otherwise specified herein or noted on the Plans, stainless steel and wrought metals shall meet the requirements of the following standards (current edition):


   Malleable Iron Castings: ASTM A 47, grade as selected.

   Stainless Steel Plates, Shapes, Bars, Tubes shall be AISI Type 304 (18-8) mill finish.

   Stainless Steel Castings shall be AISI Type 304 conforming to ASTM A 296, Iron-Chromium-Nickel Alloy.

3. Non-Ferrous Metals:

   Aluminum Bar Grating: ASTM B 221, Alloy 6061 or 6063-T6 for bearing bars; ASTM B 221 or B 210 for cross bars or bent connecting bars.

   Aluminum Extrusions: ASTM B 221; alloy 6063-T5, except alloy 6005-T5 for pipe; unless otherwise indicated.

   Clear anodized finish AA-M21C11A41, unless otherwise indicated.

   Aluminum Sheet or Plate: ASTM B 209; alloy 6061-T4; unless otherwise indicated. Mill finish.

4. Fasteners:

   General: Provide zinc-coated fasteners for exterior use or where built into exterior walls. Provide AISI Type 303, stainless steel fasteners where exposed to liquids of treatment process, for connecting aluminum or where noted to be stainless steel. Select fasteners for the type, grade and class required.

   Bolts and Nuts: Regular hexagon head type, ASTM A 307, Grade A.


Concrete & Masonry Anchorage Devices: Expansion shields, FS FF-S325, Galvanized or Stainless Steel. Wedge type expansion anchors take "Kwik-Bolt" by HILTI Tulsa, Oklahoma or equal, size as noted on the Drawings. Length shall provide minimum embedment in concrete as specified by manufacturer's literature.

Toggle Bolts: Tumble-wing type, FS FF-B-588, type, class, and style as required.

Lock Washers: Helical spring type carbon steel, FS FF-W-84.

F. FABRICATION, GENERAL

Use materials of size and thickness shown or, if not shown, of required size and thickness to produce strength and durability in finished product. Work to dimensions shown or accepted on shop drawings, using industry proven details of fabrication and support. Use type of materials shown or specified for various components of work.

Form exposed work true to line and level with accurate angles and surfaces and straight sharp edges. Ease exposed edges to a radius of approximately 1/32" unless otherwise shown. Form bent metal corners to smallest radius possible without causing grain separation or otherwise impairing work.

Weld corners and seams continuously, complying with AWS recommendations. At exposed connections, grind exposed welds smooth and flush to match and blend with adjoining surfaces.

Form exposed connections with hairline joints, flush and smooth, using concealed fasteners wherever possible. Use exposed fasteners of type shown or, if not shown, use phillips flat-head (countersunk) screws or bolts.

Provide for anchorage of type shown, coordinated with supporting structure. Fabricate and space anchoring devices to provide adequate support for intended use.

Cut, reinforce, drill and tap miscellaneous metal work as indicated to receive finish hardware and similar items.

G. PAINTING/COATING

All aluminum surfaces that will be in contact with concrete, steel or other dissimilar material shall be coated with asphaltic paint or aluminum impregnated caulking.
MISCELLANEOUS METALS

5.2-4

1. CHECKERED PLATE

Shall be standard checkered aluminum plate complete with angle frames and fasteners of thickness shown and located where shown on the drawings.

Additionally, Contractor shall be familiar with dissimilar metals corrosive issues and provide isolation materials or coatings appropriate to the installed project equipment and components to minimize future corrosion issues.

H. LADDERS

All ladders unless otherwise indicated, shall have flat bar side rails with eased edges spaced 20" o.c. with 3/4" diameter bar rungs welded to siderails at 12" maximum vertical spacing. Ladders shall be securely fastened to supporting construction beyond 42" above top rung except where prohibited by overhead or other construction. Where steel ladders are required by the drawings, provide galvanized anchor bolts or expansion anchors. Where aluminum ladders are required by the drawings provide stainless steel anchor bolts or expansion anchors.

I. GRATING

1. General: Use materials of the size and thickness shown, or if not shown, of the size recommended by NAAMM tables. Work to the dimensions shown or accepted on shop drawings, using proven details of fabrication and support. Use the type of materials shown or specified for the various components of the work. Comply with NAAMM "Metal Bar Grating Manual" and as herein specified. Except where noted otherwise, provide removable grating sections with end-banding bars and 4 stud bolts with washers and nuts unless otherwise indicated. Notch gratings for penetrations as indicated. Layout units to allow grating removal without disturbing items penetrating grating. All grating to be removable unless otherwise noted.

J. GRATING

Provide banding for openings in grating separated by more than 4 bearing bars, unless otherwise indicated. Notching of bearing bars at supports to maintain elevations will not be permitted.

K. GRATING

Provide banding for openings in grating separated by more than 4 bearing bars, unless otherwise indicated. Notching of bearing bars at supports to maintain elevations will not be permitted.
Weld stud bolts to receive saddle clip anchors to supporting metal members.

2. **Aluminum Grating:** All aluminum grating shall be "Rectangular Pressure locked", KPL-19-4 Series, type as manufactured by Klemp Corporation; or equal. Bearing bar shall be 1¼" deep x 1/8" thick minimum spaced at 1-3/16" centers unless noted otherwise on the drawings. Provide aluminum clip anchors and stud bolts where grate is supported by aluminum members and stainless steel slip anchors and stud bolts where grade is supported by steel members. Coat surfaces in contact with concrete or steel with asphaltic paint or aluminum impregnated caulking compound or other approved permanent insulation. Stair treads to have checkered plate or abrasive nosings.

3. **Aluminum Grating Treads:** All aluminum grating treads shall be pressure-locked rectangular bar "KPL-19-4" as manufactured by "Klemp Corp." or equal. Bearing bars shall be 1-1/2" x 3/16" minimum unless noted otherwise on drawings. Treads shall have cast aluminum abrasive nosings.

4. To be considered equal a grating or tread must have the same load capacity as the size grating noted on the drawings. One type of grating shall be used throughout the job. The depth may vary from that shown on the drawings, provided adequate provisions are made to make modifications to the bearing and anchorage details.

**K. PIPE RAILINGS**

1. **General:** Fabricate pipe railings to dimensions and details shown, with smooth rounded bends and welded joints ground smooth and flush.

   Adjust railings prior to anchoring to ensure matching alignment at butting joints. Space posts not more than 6'-0" on centers, unless otherwise shown. Plumb posts in each direction. Secure posts and rail ends to supporting construction as follows:

   Anchor posts and rail ends into concrete with epoxy grout as detailed.

   Provide removable railing sections as indicated. Furnish slip-fit metal socket or sleeve for casting into concrete. Accurately locate sleeves to match post spacing.

   Secure single rail handrails to walls with wall brackets and end fittings. Provide brackets with not less than 3" clearance from inside face of handrail to the finish wall surface. Drill wall plate portion of bracket to receive bolt, unless indicated for concealed anchorage. Locate brackets as indicated or, if not indicated, at not more than 6' - 0' o.c. Provide flush-type wall return fittings with same projection as that specified for wall brackets. Secure wall brackets and wall return fittings to
supporting construction as follows:

For concrete and solid masonry anchorage, use bolt anchor expansion shields and lag bolts.

For hollow masonry anchorage, use toggle bolts having square heads.

2. **Aluminum Pipe Railings:** Pipe handrails of aluminum shall be installed in the locations shown on the drawings.

   Horizontal aluminum handrails shall be 1 ½" schedule 40 pipe of aluminum alloy 6005-T5. Vertical posts to be 1 ½" schedule 80 pipe 6005-T5. Fittings shall be attached to the posts by internal welding. The various pieces of the rail shall be joined together by welding. After fabrication finish shall be a 180 grit belt grind with an Alumilite No. 204 Anodizing.

   Contractor may submit, for approval, 1 ½" square tube section handrail of the same strength as the 1 ½" pipe. Contractor shall be responsible for design of modifications to handrail anchor details to fit tube handrail. Submit modifications for approval of the Engineer.

L. **STAIR NOSINGS**

Provide cast aluminum abrasive nosings for all concrete stairs. All nosings are to be three (3) inches wide and have a one (1) inch lip. Nosings shall be the length of the tread less 3" at each end and have integral imbed anchors.

   Abrasive is to be #20 aluminum oxide (AL203), integrally cast into the walking surface to a minimum depth of 1/32". Fastener screws shall not protrude above that tread surface. Cross-hatching and fluting shall be 1/16" deep minimum and shall be clean, sharp, well-defined and free from washes, scabs, buckles, blow holes, knots, cuts, cracks and pin-holes. Abrasive cast aluminum to have sand blasted finish. Abrasive cast iron to have one coat of shop black paint.

M. **CONSTRUCTION CASTINGS**

Provide cast iron manhole ladder rungs as detailed. See drawings for locations, sizes, types and details. Unless otherwise indicated, units shall be McKinley Iron Works, or Neenah Foundry Co, castings or equal. Castings shall also meet ODOT standard requirements.

END OF SECTION
A. **SCOPE**

The work covered by this section includes the furnishing of all labor, materials and equipment for all caulking of doors, and for all joint sealants where required. All materials shall be brought on the job in labeled original containers and shall show quality, kind and manufacturer's name. Materials incorporated into the project shall be new and be installed within the Manufacturer’s “use by date”.

B. **SUBMITTALS**

Within sixty (60) days after award of Contract, and before any material are delivered to the job site, submit to the Engineer a complete list of all materials proposed to be furnished and installed under this portion of the work, making the submittal in accordance with the provisions of the General Conditions of these Specifications.

C. **MATERIALS**

Caulking Compound shall be an elastic waterproof acrylic latex caulking compound. Caulking compound shall be "Sonolac" as manufactured by Sonneborn Building Products Division, Contech, Inc., Minneapolis, Minnesota; "AC-20 Acrylic Latex" by Pecora Corp., Harleysville, Pennsylvania, or approved equal.

Color shall match adjacent work. Deliver caulking compound in manufacturer's original sealed containers.

Sealant: Polysulfide base sealant based on liquid polysulfide polymer manufactured by Thiokol Chemical Corporation, bearing Thiokol Chemical Corporation's "Tested and Approved Seal". Sealant shall be delivered to the job site in sealed containers, each bearing a "Tested and Approved" seal, manufacturer's name, and product designation. Sealant shall be two (2) part polysulfide base sealant conforming to Thiokol's Building Trade Performance Specification as follows:

- Class A (self-leveling) for joints in horizontal surfaces.
- Class B (non-sag) for joints in vertical surfaces.

Type I (Hardness: 20-35 Shore A) for caulking, glazing and sealing vertical surfaces and non traffic bearing horizontal surfaces.

Type II (Hardness: 35-45 Shore A) for caulking and sealing horizontal surfaces subject to foot and light vehicular traffic, or abrasion.
Thiokol shall be "Synthacaulk GC-5" by Pecora Corp., Harleysville, Pennsylvania; "Sonolastic Two Part" by Sonneborn Building Products Division, Conotech, Inc., or approved equal. Color shall match the adjacent materials as closely as possible. Colors shall be selected by the Engineer. Where stock colors are not acceptable, special colors shall be prepared and furnished, as approved by the Engineer. Submit cured samples for Engineer's color selection.

Joint Filler: Back-up material for caulking and sealant shall be compressible in nature and shall have a proven record of compatibility with the sealant used. Glassyard, PVC, Butyl or neoprene rod is acceptable -- expanded polyethylene foam, polyurethane foam, and similar gas-expanded foams are not acceptable.

D. INSTALLATION

Location: Polysulfide sealant shall be used for caulking all exterior joints of any type and elsewhere as indicated. Elastic caulking may be used for interior joints not requiring polysulfied sealant. Set all exterior thresholds in caulking. Caulk all joints in masonry walls; between masonry and concrete intersections; around all windows, door frames, louvers, pipes and other penetrations through walls, floors, and ceilings; joints in metal panels, fascias, etc., and all other joints required for a weathertight and/or neat workmanlike installation.

Application: Thoroughly clean all surfaces to be caulked so they will be clean, free from loose dirt, grease, etc., and dry. Surfaces that are to be caulked with polysulfide sealant must first be cleaned with Methyl-Ethyl- Keytone in strict accordance with manufacturer's directions. Install joint filler back-up material to provide proper caulking depth to width ratio according to sealant manufacturer's recommendations. Apply caulking with a gun with proper size nozzle. Use sufficient pressure to fill all voids and joints solidly. Remove excess caulking and leave surfaces neat, even, smooth, and clean; free of sags, blisters and irregularities. Application shall be according to manufacturer's directions and at least three (3) weeks ahead of painting. Where and to extent possible, caulk joints shall be applied to joint being put together and to joint after components are installed. An example of this would be at an exterior door jamb would have caulk under the threshold jamb area and outside threshold jamb area after door installation is completed. Other areas might include flashing set in a bed of caulk or surface mounted frames where required.

E. CLEAN-UP

Upon completion of the work, all caulking and sealing compounds shall be removed from surrounding areas and all joints checked for water tightness and touched up as required. It shall be the Contractor's responsibility to provide a weathertight building.

END OF SECTION
A. GENERAL:

The work to be performed under this section of the Specifications shall consist of furnishing all labor, materials, and equipment necessary for painting all new pumps, exposed pipe, valves and fittings, hangers, supports, electrical conduits, metal work, structural steel, miscellaneous steel, concrete block, and equipment as specified herein. Existing facilities shall be repainted where specified on the plans.

All metal surfaces to be painted shall be sound, clean and free of harmful scale, rust, dirt, oil, grease, moisture, or any other foreign matter which might, in any way, lessen the life or usefulness of the coating.

All metal shall be smooth and free from blisters, rough corners, pits, dents or other imperfections before painting. Pits and dents shall be filled and the metal ground smooth where required.

Shop coated surfaces shall be thoroughly cleaned before the application of subsequent paint coats in the field.

 Paints and similar materials shall be mixed in vessels of adequate capacity. All paints shall be thoroughly stirred before being taken from the containers, shall be kept stirred while using, and all ready-mixed paints shall be applied exactly as received from the manufacturer without addition of any kind of a drier or thinner except as permitted or directed by the Engineer.

All painting at the site of the work is hereby defined as field painting and shall be under the observation of the Engineer to the extent that he shall determine where and when painting meets specification. All surfaces to be painted shall have their readiness for painting approved by the Engineer before work is started.

In all cases, paints and coatings shall be applied according to manufacturer’s recommendations.

Surfaces of exposed members inaccessible after erection shall be cleaned and painted before erection.

No painting shall be done when the temperature is below 50°F, when rain is falling, during fog, or until moisture on the surfaces to be painted has completely disappeared.

Painting found defective shall be removed and the surface repainted as directed by the Engineer.
Aluminum and galvanized members shall not be painted except where specifically noted on drawings and specifications.

B.  SHOP PAINTING

Certain items which will be subjected to immersion in water or sewage in the finished work as described and set out hereinafter shall not receive a shop coat of primer or paint but shall receive in the field the specified surface preparation, primer, and finish paint coats. Items so specified for painting entirely in the field, but delivered to the job site already primed, shall be sandblasted to remove any coatings applied in the shop and then receive the coatings specified.

Items specified for shop priming shall receive one (1) shop coat of the primer specified. In all cases, shop primer shall be compatible with the field coat specified and be from the same manufacturer.

C.  SURFACE PREPARATION FERROUS METALS, PROCESS EQUIPMENT

Surface preparation of all ferrous metal to be primed in the shop shall have all rust, dust and scale, as well as all other foreign substances, removed by sandblasting or pickling. Cleaned metal shall be primed or pretreated immediately after cleaning to prevent new rusting. All ferrous metals not primed in the shop shall be sandblasted in the field prior to application of the primer, pretreatment or paint. Grades of sandblasting shall be as indicated for the specific application below and shall conform to the following definitions:

- White Meal Blast  - NACE No. 1 or SSPC-SP-5
- Near White Metal Blast - NACE No. 2 or SSPC-SP-10
- Commercial Blast - NACE No. 3 or SSPC-SP-6
- Brush Off Blast - NACE No. 4 or SSPC-SP-7

Unless otherwise specified, surface preparation shall be equivalent to NACE No. 3.

D.  SURFACE PREPARATION - ARCHITECTURAL AND STRUCTURAL MATERIALS

1.  General:

Listing below does not necessarily imply that each and every substrate condition listed will be encountered in this Project.
Perform all preparation and cleaning procedures in strict accordance with the paint manufacturer’s instructions and as herein specified, for each particular substrate condition.

Remove all hardware, hardware accessories, machined surfaces, plates, lighting fixtures, and similar items in place and not to be finish painted, or provide surface-applied protection prior to surface preparation and painting operations. Remove, if necessary, for the complete painting of the items and adjacent surfaces. Following completion of painting of each space or area, reinstall the removed items by workmen skilled in the trades involved.

Clean surfaces to be painted before applying paint or surface treatments. Remove oil and grease with clean cloths and cleaning solvents prior to mechanical cleaning. Program the cleaning and painting so that dust and other contaminants from the cleaning process will not fall in wet, newly painted surfaces.

2. Cementitious Materials:

Prepare cementitious surfaces of concrete, concrete block, cement plaster and cement-asbestos board to be painted by removing all efflorescence, chalk, dust, dirt, grease, oils and by roughening as required to remove glaze.

Determine the alkalinity and moisture content of the surfaces to be painted by performing appropriate tests. If the surfaces are found to be sufficiently alkaline to cause blistering and burning of the finish paint, correct this condition before application of paint.

Do not paint over surfaces where the moisture content exceeds 8%, unless otherwise permitted in the manufacturer’s printed directions.

3. Structural and Miscellaneous Ferrous Metals (Non Process)

Clean non-galvanized, ferrous surfaces that have not been shop-coated of all oil, grease, dirt, loose mill scale and other foreign substances by solvent or mechanical cleaning, complying with Steel Structures Painting Council (SSPC) – SP5.

Touch-up shop-applied prime coats which have damaged or bare areas. Wire-brush, solvent clean, and touch-up with the same primer as the shop coat.
4. Galvanized Surfaces:

Where painting is required, clean free of oil and surface contaminants with an acceptable non-petroleum based solvent. Approximately 24 hours before application of prime coat (and immediately after cleaning), chemically treat surfaces with a phosphoric acid or copper sulphate solution, applied according to directions of manufacturer of paint being used.

E. PAINTS

The paints and paint products listed below are as manufactured by Tnemec Company, Inc., and are intended to establish standards of quality. Paint products for this project shall be equal in all respects to the products listed. No request for substitution will be considered which decreases the film thickness designated and/or the number of coats to be applied, or which offers a change from the generic type of coating specified. Any request for substitution shall contain the full name of each product, descriptive literature, directions for use, generic type, nonvolatile content by volume, and a list of at least ten (10) water treatment plants where each of the coatings has been used on new construction and has rendered satisfactory service for at least three (3) years. Submitted paint system shall be used throughout entire project.

a. Series 27 F.C. Typoxy; 3 mils/coat.
b. Series 114 H.B. Tneme-Tufcoat; 3 mils/coat.
c. Series 36 undercoater; 2 mils/coat.
d. Series 46H-413 Tneme-Tar; 10 mils/coat.
e. Series 54-562 Modified Epoxy Masonry Filler; 10 mils/coat.
f. Series 66 Hi-Build Epoxoline; 4 mils/coat.
g. Series 181 W. B. Tneme-Crete; 5 mils/coat.
h. Series 74 Endura-Shield; 2 mils/coat.
i. Series 104 H.S. Epoxy; 4 mils intermediate/9 mils final.
j. Series 113 Tneme Tufcoat; 4 mils/coat.

Each coat shall have the minimum dry film thickness indicated above. All coats of paint for any particular surface shall be from the same manufacturer.

F. PAINTING SCHEDULE

The number of coats shall be not less than called for hereunder. Letter designation of various coats of paint refer to the same letter designation of paints given in the preceding subsection. Colors to be selected by the Owner from the standard color line of each particular paint type and manufacturer.
Exposed water treatment plant pipe shall be color coded per Appendix A of Title 252 Chapter 656 “Public Water Supply Construction Standards”.

Surface areas to be painted include, but are not limited to, the following items:

1. Not Used

2. Pump Motors: Manufacturer’s Standard Paint System.

3. All indoor exposed Iron Pipe, Valves, Fittings and Appurtenances: Field sandblast to NACE No. 3; Field coat - two (2) coats of (f).

4. All outdoor exposed Iron Pipe, Valves, Fittings and Appurtenances: Field Sand Blast to NACE No. 3; Field coat - one (1) coat of (f) and two (2) coats of (h).

5. All Submerged Iron Pipe: Field Sand Blast NACE No. 2; Field coat - two (2) coats of (d).

6. Exterior Hollow Metal Doors and Frames and Miscellaneous Steel Items: Shop coat - one (1) coat of (a) and two (2) coats of (f).

7. Interior Hollow Metal Doors and Frames and Miscellaneous Steel Items: Shop coat - one (1) coat of (a) and two (2) coats of (f).

8. Interior Concrete Block Masonry General Areas: One (1) coat of (e) and two (2) coats of (b).

9. Exterior Surfaces All Concrete Block Masonry: Two (2) coats of (g).

10. Submerged Steel Surfaces: Sand Blast NACE No. 2; Shop coat - one (1) coat of (i) primer (4.0 miles) and one (1) coat of (i) finish coat (9.0 mils).

11. Exterior Steel Surfaces: Sand Blast NACE No. 3; One (1) coat of (i) primer (4.0 miles) and one (1) coat of (i) finish coat (9.0 mils).

12. Existing and New Wood Siding and Trim (Fascia Board): One (1) coat of (c) two (2) coats of (j). Color to match existing, clean siding and trim as required before priming and painting.
G. PAINT APPLICATION - ARCHITECTURAL AND STRUCTURAL MATERIALS

1. General:
   a. Apply paint with brush, roller, spray or other acceptable practice in accordance with the manufacturer’s directions. Use brushes best suited for the type of material being applied. Use rollers of carpet, velvet back, or high pile sheep’s wool as recommended by the paint manufacturer for material and texture required.
   
   b. The number of coats and paint film thickness required is the same regardless of the application method. Do not apply succeeding coats until the previous coat has completely dried. Sand between each enamel or varnish coat application with fine sandpaper.
   
   c. Apply additional coats when undercoats, stains, or other conditions show through the final coat of paint, until the paint film is of uniform finish, color and appearance. Give special attention to insure that all surfaces, including edges, corners, crevices, welds and exposed fasteners receive a film thickness equivalent to that of flat surfaces.
   
   d. Paint surfaces behind movable equipment and furniture the same as similar exposed surfaces. Paint surfaces behind permanently-fixed equipment or furniture with prime coat only.
   
   e. Paint interior surfaces of ducts, where visible through registers or grilles, with a flat, non-specular black paint, before final installation of equipment.
   
   f. Paint the back sides of access panels, removable or hinged covers to match the exposed surfaces.
   
   g. Recoat primed and sealed walls and ceilings where there is evidence of suction spots or unsealed areas in first coat, to assure a finish coat with no burn-through or other defects due to insufficient sealing.

2. Brush Application:
   a. Brush-out and work all brush coats onto the surfaces in an even film. Cloudiness, spotting, holidays, laps, brush marks, runs, sags, ropiness, or other surface imperfections will not be acceptable. Neatly draw all glass and color break lines.
b. Brush apply all primer or first coats, unless otherwise permitted to use mechanical applicators.

3. Mechanical Applicators:
   a. Use mechanical methods for paint application only when permitted by governing ordinances and trade union regulations. If permitted, limit to only those surfaces impracticable for brush applications.
   b. Limit roller applications (generally) to interior wall and ceiling finishes for second and third coats. Apply each roller coat to provide the equivalent hiding as brush-applied coats.
   c. Confine spray application (generally) to metal framework, siding, decking, wire mesh and similar surfaces where hand brush work would be inferior and other surfaces specifically recommended by paint manufacturer.
   d. Wherever spray application is used, apply each coat to provide the equivalent hiding of brush-applied coats. Do not double back with spray equipment for the purpose of building up film thickness of two coats in one pass.

4. Required Condition of Completed Work:
   Must match approved samples for color, texture and coverage. Remove, refinish, or repaint work not in compliance with specified requirements.

5. Protection:
   a. Protect work of other trades, whether to be painted or not, against damage by the painting and finishing work. Correct any damages by cleaning, repairing or replacing and repainting, as acceptable to the Engineer.
   b. Provide “Wet Paint” signs as required to protect newly painted finishes. Remove temporary protective wrappings provided by others for protection of their work after completion of painting operations.

6. Clean-up:
   a. During the progress of the work, remove from the site all discarded paint materials, rubbish, cans and rags at the end of each work day.
b. Upon completion of painting work, clean all paint-spattered surfaces. Remove spattered paint by proper methods of washing and scraping, using care not to scratch or otherwise damage finished surfaces.

c. At the completion of work of other trades, touch-up and restore all damaged or defaced painted surfaces.

END OF SECTION
PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Requirements for surface preparation, repairs and solventless epoxy coating application to interior walls and ceiling of manholes, wet wells and vaults.

B. Protective coating shall be applied to all interior surfaces of the following structures:

1. Manhole A
2. Influent Cut Off Vault
3. Lift Station Grinder Well
4. Lift Station Wet Wells

1.2 REFERENCES

A. ASTM D638 - Tensile Properties of Plastics.


C. ASTM D695 - Compressive Properties of Rigid Plastics.

D. ASTM D4541 - Pull-off Strength of Coatings Using a Portable Adhesion Tester.

E. ASTM D2584 - Volatile Matter Content.

F. ASTM D2240 - Durometer Hardness, Type D.

G. ASTM D543 - Resistance of Plastics to Chemical Reagents.


I. ASTM C348 - Flexural Strength Hydraulic Cement Mortars.

J. ASTM C396 - Compressive Strength of Cement Mortars.

K. ACI 506.2-77 - Specifications for Materials, Proportioning, and Application of Shotcrete.

L. ASTM C579 - Compressive Strength of Chemically Setting Silicate and Silica Chemical Resistant Mortars.

M. ASTM - The published standards of the American Society for Testing
and Materials, West Conshohocken, PA.

N. NACE - The published standards of National Association of Corrosion Engineers (NACE International), Houston, TX.

O. SSPC - The published standards of the Steel Structures Painting Council, Pittsburgh, PA.

1.3 SUBMITTALS

A. The following items shall be submitted:

1. Technical data sheet on each product used, including ASTM test results indicating the product conforms to and is suitable for its intended use per these specifications.

2. Safety Data Sheets (SDS) for each product used.

3. Project specific guidelines and recommendations.

4. Qualification of Applicator:

   a. Manufacturer certification that Applicator has been trained and approved in the handling, mixing and application of the products to be used.

   b. Certification by the protective coating manufacturer that the equipment to be used for applying the products has been approved and Applicator personnel have been trained and certified for proper use of the equipment.

   c. Five (5) recent references of Applicator indicating successful application of a high-build solventless epoxy coating by spray application.

   d. Proof of any necessary federal, state or local permits or licenses necessary for the project.

5. Design details for any additional ancillary systems and equipment to be used in site and surface preparation, application and testing.


B Samples:
1. Submit one product sample coupon.

C. Submit schedule for products under Part 2, Products. Define location of application for each product. As part of coatings schedule, submit color chart for Owner and Engineer’s selection.

1.4 QUALITY ASSURANCE

A. Applicator shall initiate and enforce quality control procedures consistent with applicable ASTM, NACE and SSPC standards and the protective coating manufacturer's recommendations.

B. A protective coating manufacturer's representative shall provide at least two days of on-site observation, including a Coating Kick-off Onsite Meeting prior to any work and site specific recommendations relative to surface preparation, handling, application and curing of its products. In addition, the manufacturer shall provide written certification that Applicator has been trained and certified by the manufacturer to handle and apply their products. The Manufacturer’s Representative shall also provide a final site visit during final inspections, as applicable and required to resolve any outstanding topics.

C. Provide a completed copy of a Daily Coating Inspection Report documenting the 3.7 application details and other pertinent application information including, but not limited to: Manufacture’s material product information being applied, project information, application location, date, ambient temperature, surface temperature, humidity, dew point, surface preparation achieved, work hours applied and other relevant application information. Submit Daily Coating Inspection Report “form” with the paint submittal(s) for approval. At the end of each workday’s activities, submit the applicator signed and dated Daily Coating Inspection Report form to the Owners Representative. Transmit a complete package of the Daily Coating Inspection Reports as an informational submittal package at the end of the project to the Engineer.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Materials are to be kept dry, protected from weather and stored under cover.

B. Protective coating materials are to be stored between 50 deg F and 90 deg F. Do not store near flame, heat or strong oxidants.

C. Protective coating materials are to be handled according to their material safety data sheets.

1.6 SITE CONDITIONS
A. Applicator shall conform with all local, state and federal regulations including those set forth by OSHA, RCRA and the EPA and any other applicable authorities.

1.7 WARRANTY

A. Applicator shall warrant all work against defects in materials and workmanship for a period of one (1) year, unless otherwise noted, from the date of final acceptance of the project. Applicator shall, within a reasonable time after receipt of written notice thereof, repair defects in materials or workmanship which may develop during said one (1) year period, and any damage to other work caused by such defects or the repairing of same, at his own expense and without cost to the Owner.

B. Provide and coordinate an onsite Paint-Coating Kick-off Meeting to discuss project scope, materials, applications and special project details unique to this project. Manufacture Representative onsite time should consist of four (4) hours minimum, on two separate site visits, one during Kick-Off Meeting and one for final inspections.

PART II - MATERIALS

2.1 EXISTING PRODUCTS

A. Standard Portland cement or new concrete (not quick setting high strength cement) must be well cured prior to application of the protective coating. Generally, 28 days is adequate cure time for standard Portland. If earlier application is desired, compressive or tensile strength of the concrete can be tested to determine if acceptable cure has occurred. (Note: Bond strength of the coating to the concrete surface is generally limited to the tensile strength of the concrete itself. Engineer may require Elcometer pull tests to determine suitability of concrete for coating)

B. Cementitious patching and repair materials should not be used unless their manufacturer provides information as to its suitability for topcoating with an epoxy coating. Project specific submittals should be provided including application, cure time and surface preparation procedures, which permit optimum bond strength with the epoxy coating.

C. Remove existing coatings prior to application of the new protective coating. Applicator is to maintain strict adherence to applicable NACE and SSPC recommendations with regard to proper surface preparation and compatibility with existing coatings.

2.2 REPAIR MATERIALS
A. Repair materials shall be used to fill voids, structurally reinforce and/or rebuild surfaces, etc. as determined necessary by the engineer and protective coating applicator. Repair materials must be compatible with the specified epoxy coating and shall be applied in accordance with the manufacturer’s recommendations.

B. As an example, the following products may be accepted and approved by the protective coating manufacturer and could be used within the specifications:

1. 100% solids epoxy grout that can be troweled or sprayed and specifically formulated for optimum epoxy topcoating compatibility. The epoxy grout manufacturer shall provide instructions for epoxy topcoating procedures.

2. Factory blended, rapid setting, high early strength, fiber reinforced, non-shrink repair mortar that can be trowelled or pneumatically spray applied may be approved if specifically formulated to be suitable for epoxy topcoating. Such repair mortars should not be used unless their manufacturer provides information as to its suitability for topcoating with an epoxy coating. Project specific submittals should be provided including application, cure time and surface preparation procedures which permit optimum bond strength with the epoxy coating.

3. Shotcrete shall conform to all requirements of ACI-506.2-77 as published by the American Concrete Institute, Detroit, MI except as modified by these specifications. Shotcrete composed of Portland Cement, aggregate and water so proportioned as to produce a concrete suitable for pneumatic application. Shotcrete ingredients shall be selected, proportioned in such a manner as will produce sound concrete that is strong, dense and suitable for polymer topcoating. Cured shotcrete shall have a minimum surface tensile strength of 300 psi. No coatings shall be applied prior to a full 28 day cure unless test patches of coatings exhibit acceptable bonding characteristics and no outgassing as prescribed herein or the repair mortar manufacturer certifies acceptable topcoating parameters.

2.3 PROTECTIVE COATING MATERIAL

A. Protective Coating System shall be a 100% solid, solventless two-component epoxy resin system filled with select fillers to minimize permeability and provide sag resistance. Coating shall be light reflective, bright light blue in color. Acceptable coating systems are as follows:

2. SLS-30 Ultra-Build Epoxy Lining System, as manufactured by Citadel Technologies, Tulsa, Oklahoma. Total Thickness: 80 mils minimum per Manufacture’s recommendations. Two coats minimum.

3. Tnemec Series 434 Perma-Shield H2S as manufactured by Tnemec, Inc Kansas City, MO. Total Thickness: 80 mils minimum per Manufacture’s recommendations. Two coats minimum.

4. Saueriesen Sewergard 210S system with Saueriesen 120 and 500 PenePrine as manufactured by Saueriesen Inc. Total Thickness: 80 mils minimum per Manufacture’s recommendations. Two coats minimum.

5. Pre-Approved Equal (10 days before bid date). Coating system must be light reflective, light blue in color.

<table>
<thead>
<tr>
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<th>Value</th>
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<tr>
<td>Product type</td>
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<tr>
<td>Color</td>
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Chemical Resistance to:

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<tr>
<td>Sodium Hydroxide, 20%</td>
<td>Immersion Service</td>
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</table>

2.4 PROTECTIVE COATING APPLICATION EQUIPMENT

A. Specifically designed, or approved for use by the protective coating manufacturer, heated plural component spray equipment for use in the application of the specified protective coating.

2.5 REPAIR MORTAR SPRAY APPLICATION EQUIPMENT (if spray applied)

A. Specifically designed, or approved for use by the repair mortar material manufacturer, for continuous mixing and spraying of the material.

PART III - EXECUTION

3.1 ACCEPTABLE APPLICATORS
A. Repair mortar applicators should be trained to properly apply the cementitious mortar according to manufacturer's recommendations.

B. Protective coating must be applied by a Certified Applicator of the protective coating manufacturer and according to manufacturer specifications.

3.2 EXAMINATION

A. All structures to be coated shall be readily accessible to Applicator.

B. Appropriate actions shall be taken to comply with local, state and federal regulatory and other applicable agencies with regard to environment, health and safety.

C. Any active flows shall be dammed, plugged or diverted as required to ensure that the liquid flow is maintained below the surfaces to be coated.

D. Installation of the protective coating shall not commence until the concrete substrate has properly cured and been prepared in accordance with these specifications.

E. Temperature of the surface to be coated should be maintained between 50 deg F and 120 deg F during application or as required by the Manufactures recommendations. Prior to and during application, care should be taken to avoid exposure of direct sunlight or other intense heat source to the structure being coated. Where varying surface temperatures do exist, care should be taken to apply the coating when the surface temperature is falling versus rising (ie. late afternoon into evening … as opposed to … morning into afternoon).

3.3 SURFACE PREPARATION

A. Applicator shall inspect all surfaces specified to receive a protective coating prior to surface preparation. Applicator shall notify Owner of any noticeable disparity in the surfaces which may interfere with the proper preparation or application of the repair mortar and protective coating.

B. All concrete that is not sound or has been damaged by chemical exposure shall be removed to a sound concrete surface.

C. All contaminants including: oils, grease, unsound or incompatible existing coatings, waxes, form release, curing compounds, efflorescence, sealers, salts, or other contaminants shall be removed.

D. Surface preparation method(s) should be based upon the conditions of the substrate and the requirements of the epoxy protective coating to be applied.
E. All surfaces shall be repaired as required by the epoxy protective coating system in the intended service condition.

F. Surfaces to receive protective coating shall be cleaned and abraded to produce a sound concrete surface with adequate profile and porosity to provide a strong bond between the protective coating and the substrate. Generally, this can be achieved with a high pressure water cleaning using equipment capable of 5,000 psi at 4 gpm. Other methods such as high pressure water jetting (refer to NACE Standard No. 5/SSPC-SP12), abrasive blasting, shotblasting, grinding, scarifying or acid etching may also be used. Detergent water cleaning and hot water blasting may be necessary to remove oils, grease or other hydrocarbon residues from the concrete. Whichever method(s) are used, they shall be performed in a manner that provides a uniform, sound clean neutralized surface that is not excessively damaged.

G. A mild chlorine solution may be used to neutralize the surface to diminish microbiological bacteria growth prior to final rinse and coating.

H. Infiltration shall be stopped by using a material which is compatible with the specified repair mortar and is suitable for topcoating with the specified epoxy protective coating.

I. Test prepared surfaces after cleaning but prior to application of the epoxy coating to determine if a specific pH or moisture content of the concrete is required according to manufacturer's recommendations.

J. Special attention shall be made to remove all form panel and formwork “slobbers” by grinding or other method acceptable to the costing manufacture. Additionally, all concrete corner which receive concrete resistant coating shall have chamfered corners and additional grinding to make them “softer” edges for coatings at all exposed edges which receive coating.

K. All surfaces should be inspected during surface preparations and before the repair mortar is applied.

L. Contractor shall provide termination details per Manufacture’s recommendations at all imbedded items. Areas of “sharp”, chamfered corner or corners shall be ground with mechanical grinding to provide smooth surface for coating application.

3.4 APPLICATION OF REPAIR MATERIALS

A. Areas where structural steel has been exposed or removed shall be repaired in accordance with the Project Engineer's recommendations.
B. Repair materials shall meet the specifications contained herein. The materials shall be trowel or spray applied utilizing proper equipment on to specified surfaces. The material thickness shall be specified by the Project Engineer according to Owner's requirements and manufacturer's recommendations.

C. Cementitious repair materials shall be trowelled to provide a smooth surface with an average profile equivalent to coarse sandpaper to optimally receive the protective coating. No bugholes or honeycomb surfaces should remain after the final trowel procedure of the repair mortar.

D. The repair materials shall be permitted to cure according to manufacturer recommendations.

E. Application of the repair materials, if not performed by the coating certified applicator, should be inspected by the protective coating manufacturer's representative or certified applicator to ensure proper finishing for suitability to receive the specified coating.

F. After abrasive blast and leak repairs have been performed, all surfaces shall be inspected for remaining laitance prior to protective coating application. Any evidence of remaining contamination or laitance shall be removed by additional abrasive blast, shotblast or other approved method. If repair materials are used, refer to these specifications for surface preparation. Areas to be coated must also be prepared in accordance with these specifications after receiving a cementitious repair mortar and prior to application of the epoxy coating.

G. All surfaces should be inspected during and after preparation and before the protective coating is applied.

3.6 APPLICATION OF PROTECTIVE COATING

A. Application procedures shall conform to the recommendations of the protective coating manufacturer, including material handling, mixing, environmental controls during application, safety, and spray equipment.

B. The spray equipment shall be specifically designed to accurately ratio and apply the specified protective coating materials and shall be regularly maintained and in proper working order.

C. The protective coating material must be spray applied by a Certified Applicator of the protective coating manufacturer.

D. Specified surfaces shall be coated by spray application of a moisture tolerant, solventless, 100% solids, self-priming epoxy protective coating as further
described herein. The coating will be applied to minimum and average wet film thicknesses of 100.

E. Airless spray application equipment approved by the coating manufacturer shall be used to apply each coat of the protective coating to avoid any potential contamination from compressed air oil which may encourage inter-coat delamination. Air assisted spray application equipment may be acceptable, especially for thinner coats (<10 mils), only if the air source is filtered to completely remove all oil and water.

F. If necessary, subsequent topcoating or additional coats of the protective coating should occur as soon as the basecoat becomes tack free, ideally within 12 hours but no later than 24 hours after the prior coat has been applied at 75 deg F unless additional prior coat surface preparation is performed. The protective coating manufacturer must be consulted for any additional-coat surface preparation guidelines if necessary.

G. (Optional) Fiberglass woven-roving fabric may be rolled into the resin or chopped glass spray applied with the resin for added tensile and flexural strength where desired, such as the crown of pipes. Sloped surfaces of the floor may be made non-skid by broadcasting aluminum oxide or silica sand into the surface prior to gelation.

H. Provide a completed copy of a Daily Coating Inspection Report to the City at the end of each workday documenting application details, including: Manufacture’s material product information being applied, project information, application location, date, ambient temperature, surface temperature, humidity, dew point, work hours applied and Daily signed by the Applicator.

I. Coatings shall be installed completely prior to the installation of any surface mounted anchoring, fasteners, devices or equipment. All bug holes and imperfections in the cast concrete shall be repaired prior to coating application per Manufacture’s recommendations.

3.7 TESTING AND INSPECTION

A. During application a wet film thickness gage, such as those available through Paul N. Gardner Company, Inc. meeting ASTM D4414 - Standard Practice for Measurement of Wet Film Thickness of Organic Coatings by Notched Gages, shall be used to ensure a monolithic coating and uniform thickness during application.

B. After the protective coating has set hard to the touch it shall be inspected with high-voltage holiday detection equipment. An induced holiday shall be made on to the coated concrete surface and shall serve to determine the
minimum/maximum voltage to be used to test the coating for holidays at that particular area. The spark tester shall be initially set at 100 volts per 1 mil (25 microns) of film thickness applied but may be adjusted as necessary to detect the induced holiday. All detected holidays shall be marked and repaired by abrading the coating surface with grit disk paper or other hand tooling method. A visual pin hole will be considered a holiday and the imperfection shall be repaired in accordance with the Manufacture’s recommendations. After abrading and cleaning, additional protective coating material can be hand applied to the repair area. All touch-up/repair procedures shall follow the protective coating manufacturer's recommendations. A visual “pin hole” is considered a holiday and shall be repaired.

C. Measurement of bond strength of the protective coating to the substrate can be made at regular intervals and along different sections of the structure (i.e., crown of pipe, wall, invert -- every 200 ft). Bond strength can be measured in accordance with ASTM D4541. Any areas detected to have inadequate (less than 300 psi to concrete) bond strength shall be evaluated by the Project Engineer. Further bond tests may be performed in that area to determine the extent of potentially deficient bonded area and repairs shall be made by Applicator in strict accordance with manufacturer's recommendations.

D. A final visual inspection shall be made by the Inspector and manufacturer's representative. Any deficiencies in the finished coating shall be marked and repaired according to the procedures set forth herein by Applicator.

E. The system may be put back into non-severe operational service as soon as the final inspection has taken place. However, for severe corrosion duty such as high concentrations of acids, bases or solvents, 3 to 7 days and/or force cure by heat induction to the coated surfaces may be necessary prior to returning to service. Consult coating manufacturer for further details.

END OF SECTION
A. **GENERAL**

1. **Description**

   This section covers both recessed fire extinguisher cabinets and non-recessed cabinets.

2. **Submittals**

   a. Manufacturer's Literature and Data: Fire extinguisher cabinet including installation instruction and rough opening required.

B. **PRODUCTS**

1. **Fire Extinguisher Cabinet**

   a. Semi-recessed type with flat trim of size and design shown.

2. **Fabrication**

   a. Form body of cabinet from (0.0359 inch) thick sheet steel.

   b. Fabricate door and trim from (0.0478 inch) thick sheet steel with all face joints fully welded and ground smooth.

   1. Glaze doors with (1/4 inch) thick G-19, clear acrylic sheet.

   2. Design doors to open 180 degrees.

   3. Provide continuous hinge, pull handle, and adjustable roller catch.

   c. Cabinet shall be capable of holding a 10 lb Fire Extinguisher.

3. **Finish**

   a. Finish interior of cabinet body with baked-on semigloss white enamel.

   b. Finish door, frame with manufacturer's standard baked-on prime coat suitable for field painting.

3. **Products**

   a. The cabinet shall be 9 ½” x 24” x 6” complying with ADA requirements.

   b. Suggested manufacturer is HS Fire Safety Products, Model 2409R4 by Hallmann Sales, LLC or approved equal.

   c. Provide Fire Extinguishers in the quantity and location described below.
1. Carbon Dioxide Fire Extinguisher (10 lbs) - Locate as follows:
   a. (Qty. 1ea, one) Electrical/MCC Room

2. Dry Chemical Class (B, C), (10 lbs) - Locate as follows:
   a. None Required

3. ABC Type Fire Extinguisher (10 lbs) - Locate as follows:
   a. (Qty. 4ea, four) Extra Fire Extinguisher to be located by Owner

C. EXECUTION

1. Install fire extinguisher cabinets in prepared openings and secure in accordance with manufacturer's instructions.

2. Install cabinet so that bottom of cabinet is (39 inches) above finished floor.

3. Coordinate installation of cabinets with Engineer and other trades to avoid conflicts.

End of Section
PART 1 - GENERAL

1.1 SUMMARY

A. This section of the specification describes requirements for a submersible pumping system to be installed at the TMUA Northside Wastewater Treatment Plant including a total of five (5) submersible chopper pumps. The equipment shall be installed as shown on the plans, as recommended by the supplier, and in compliance with all OSHA, local, state and federal codes and regulations.

1.2 WARRANTY

A. Pump manufacturer shall furnish to the Owner a warranty written expressly from the manufacturer to the Tulsa Metropolitan Utility Authority, covering workmanship, material, and performance deficiency under normal use and service. The full warranty shall cover 100 percent of parts and labor for at least 24 months. After that, the equipment shall be covered by a pro-rated warranty with the following minimum provisions:

1. From 25 to 39 months after acceptance: 50 percent of all replacement parts and labor for defective materials, workmanship, and performance deficiency.

2. From 40 to 60 months after acceptance: 25 percent of all replacement parts and labor for defective materials, workmanship, and performance deficiency.

B. The warranty period shall commence on the day of start-up acceptance by the Owner. Warranty shall be in printed form and previously published as the manufacturer’s standard warranty for similar manufactured units.

PART 2 - PRODUCTS

2.1 SUBMERSIBLE CHOPPER PUMPS

A. CONDITIONS OF OPERATION

Each pump shall be capable of providing the following hydraulic conditions when pumping domestic sewage:
### B. PUMP DESIGN CONFIGURATION (Wet pit installation)

Each pump shall be supplied with a minimum of 50’ feet of submersible cable (SUBCAB) suitable for each submersible pump application. Contractor to confirm length of cable required before ordering. Splices are not allowed. The power cable shall be sized according to NEC and ICEA standards and also meet with P-MSHA Approval. All similar pumps shall be supplied with the same length cable from the Manufacture for this installation.

The operating points listed above shall be within the pumps allowable operating range (AOR). Reduced speed curves showing AOR limitations shall be provided in the pump submittals.

The pump(s) shall be automatically and firmly connected to the discharge connection, guided by no less than two guide bars extending from the top of the station to the discharge connection. There shall be no need for personnel to enter the wet-well. Sealing of the pumping unit to the discharge connection shall be accomplished by a machined metal to metal watertight contact. Sealing of the discharge interface with a diaphragm, O-ring or profile gasket will not be acceptable. No portion of the pump shall bear directly on the sump floor.
Each pump shall be fitted with **40** feet of minimum **3/8” 316L SS** lifting chain. The working load of the lifting system shall be 1.7 times greater than the pump unit weight.

The pump(s) shall be manufactured by:

1. Hayward-Gordon, Inc., as provided by Haynes Equipment Company, Oklahoma City, Oklahoma
2. Vaughan Company, Inc., as provided by Bertrem products, Inc., Tulsa, Oklahoma
3. Approved alternate equipment and suppliers listed by addendum.

C. CASING

The pump casing will be constructed of ASTM A48 Cast Iron. Flanged suction and discharge connections shall conform to the requirements of ANSI B16.1, Class 125. The casing back-plate shall have a spiral cutting groove on the surface that is in close clearance to the rear flange of the impeller.

D. IMPELLER

The pump impeller shall be an open or semi-open type with sharpened vane edges incorporated into the rear of the impeller which provides cutting action against the backplate spiral groove, preventing fouling behind the impeller. Primary chopping/conditioning of materials shall be accomplished by the action of the sharpened leading edges of the impeller blades moving across the cutter bar at the intake openings with a set clearance between the impeller and cutter bar of .010” to .015”. Impeller shall be constructed of ASTM A148 cast alloy steel case hardened to minimum Rockwell C60 and shall be dynamically balanced.

E. CUTTER BAR

The casing will be fitted with a replaceable suction plate with cutter bars constructed of ASTM A148 alloy steel case hardened to minimum Rockwell C60. The surface of the suction plate facing the impeller shall have multiple radial cutting slots to prevent binding of material between it and the impeller vanes.

F. UPPER CUTTER
The area behind the impeller shall be protected from fouling by the cutting and expulsion action of sharpened vane edges in the rear of the impeller sweeping across the spiral grooves in the casing backplate.

G. DEFLECTOR NUT

The impeller shall be secured to the shaft using a deflector nut made from 410 Stainless Steel hardened to 400 BHN. The nut shall be designed to protrude in front of the cutter bars and deflect stringy materials and prevent binding.

H. BEARINGS

All bearings shall be rated for a minimum L10 life of 100,000 hours at 25% of the flow at the best efficiency point (BEP). Bearings shall be permanently lubricated with a premium moisture resistant grease containing rust inhibitors and shall be suitable for operation over a temperature range of –25 C to +120 degrees C.

I. SHAFT SEALS

Shaft Seals: Two independent, tandem mounted, mechanical face type seals shall be provided to isolate and protect the air-filled motor from the pumped media. The inner and outer seal shall be separated by an oil filled chamber. The oil chamber shall act as a barrier to trap moisture and provide sufficient time for a planned shutdown.

The lower seal faces shall be Tungsten Carbide vs. Tungsten Carbide. The upper mechanical seal shall be constructed of a carbon rotating face and a ceramic stationary face. All other seal components shall be 316SS. Mechanical seals shall be readily and commercially available from third party sources other than the pump and motor manufacturer.

J. MOISTURE PROTECTION SYSTEM

A dual (2) probe sensing system shall be provided to detect the presence of moisture within the motor. The moisture sensing probe leads shall terminate at a separately supplied conductance relay located in the control panel which shall provide an alarm in the event of moisture intrusion. The sensing relay shall either be provided or approved by the pump/motor

K. CABLE ENTRY SYSTEM
The power and control cable entry system shall be designed to provide a positive, leak-free seal to prevent liquid from entering the air filled motor housing. The design shall incorporate provisions which prevent moisture from wicking through the cable assembly even in the event that the cable jacket has been punctured. All cable shall be type SEOW-A and U.L. listed for the intended submersible service.

The power and control cable entry into the lead connection chamber shall be encapsulated for positive moisture sealing. A Buna-N cable grommet shall be provided in addition to the epoxy sealed leads. Compression type grommet fittings employed as the primary sealing system shall neither be considered equal or acceptable. Separate power and control cables shall be provided to prevent false sensor warnings.

L. ELECTRICAL

Submersible motors shall successfully operate under power supply variations per NEMA MG1-14.30. Motors shall be NEMA Design B with torque and starting current in accordance with NEMA MG-12. The submersible motors shall be of an air-filled, high efficiency design with copper windings and shall be rated for continuous full load operation. The motor construction shall be of explosion proof, TENV-TEXP design and capable of being certified for use in Class 1, Groups C & D hazardous locations by either Factory Mutual (F.M.) or Underwriters Laboratories (U.L). Motors to be capable of running for 15 minutes in air (unsubmerged). Motors shall be capable of withstanding up to 15 starts per hours and shall have a minimum 1.15 service factor.

The insulation system shall be Class F minimum, utilizing materials certified per IEEE 117, and shall be rated at a temperature of 155 degrees C. Two (2) normally closed, automatic reset, thermostats shall be connected in series and embedded in adjoining phases of the stator windings.

M. GUIDE BRACKET AND RAIL SYSTEM

The pump shall be provided with a guide system to allow easy removal without entering the wet well. The main base fixture shall be bolted to the floor and shall include a 90 degree Cast Iron elbow and mounts for two galvanized steel rails of standard schedule 40 pipe. The base fixture shall be designed to receive the connecting pump slide bracket without the need for bolts, nuts, or clamps. The pump discharge will connect to a Cast Iron slide bracket with bronze guide shoe for non-sparking design that seals against the base fixture by the weight of the pump.

N. SPARE PARTS

18TMUAAIRPLS
The following spare parts will be provided under this contact and delivered to the Plant Maintenance Department prior to start-up of related equipment.

1) Pump Seals – Once complete pump seal kit for each pump installed.
2) Standard Pump Manufacture’s recommended spare parts.

PART 3 - EXECUTION

3.1 INSTALLATION

Equipment shall be installed in accordance with the supplier’s installation instructions, and in compliance with all OSHA, local, state, and federal codes and regulations.

3.2 MANUFACTURER’S SERVICES

A. The Contractor shall require the manufacturer to furnish the services of a qualified field engineer to perform the following functions in the designed periods of time. These services are to be performed at the jobsite. A minimum of two (2) visits to the job site shall be required. A one week notice to the Owner and Engineer shall be provided for activities defined in section 3.2 Manufacture’s Services.

1. Check-out of installation, start-up of equipment and initial operator instruction. This service shall take place after all mechanical equipment associated with the control system is installed and mechanically operable.

2. After equipment is fully operational, and before Owner will assume responsibility for the operation of the equipment, the equipment manufacturer's representative shall instruct the Owner's operating personnel in the care, maintenance and proper operation of the equipment. Contractor shall submit Manufacture inspection and certification of proper installation including all data checked noting all initial details verified by Manufacture and initial set point established. Start up and certification of proper installation shall be included and submitted with the O&M

3. Provide Operation and Maintenance training. Training time required shall be in addition to time required for start-up activities noted above. Training should include a minimum of two (2) hour
of field training and class room training, as required to provide sufficient Manufacture’s recommended training.

B. Field Test

1. Prior to equipment startup, all equipment described herein shall be inspected for quiet operation, proper connections, and satisfactory performance by means of a functional test.

2. The pump and motor assembly shall be field tested to verify vibration is not in excess of the limits stated in the latest revision of Hydraulic Institute and NEMA MG 1.

3. The pump, motor, and controls shall be given an operational test in accordance with the standards of the Hydraulic Institute. Recordings of the test shall substantiate the correct performance of the equipment at the design head, capacity, speed and horsepower as specified herein.

4. Units apparently failing to meet the Specifications to the satisfaction of the Engineer must be more accurately tested in accordance with Hydraulic Institute Standards. If the pump fails the second test, the unit will be rejected, and the Contractor shall furnish a unit that will perform as specified.

C. Operation and Maintenance Materials

1. The pump manufacturer shall be responsible for supplying five (5) sets of written instructions minimum, or as further defined in specifications, which shall be sufficiently comprehensive to enable the operator to operate and maintain the pump and all equipment supplied by the manufacturer. Instructions shall assume that the operator is familiar with pumps, motors, piping, valves, and controls, but that he has not previously operated and/or maintained the exact equipment supplied.

2. The instructions shall be prepared as a system manual applicable solely to the pump and equipment supplied by the manufacturer to these specifications, and shall include those devices and equipment supplied by him.

3. Operation and maintenance instructions shall be specific to the equipment supplied in accordance with these specifications. Instruction manuals applicable to many different configurations and pumps, and which require the operator to selectively read
portions of the instructions shall not be acceptable. To clarify these types of manuals mark through all information not applicable to equipment supplied.

D. All costs for the above manufacturer functions including travel, lodging, meals, and incidentals shall be considered to have been included in the Contractor's lump sum bid price.

END OF SECTION
A. GENERAL

1. Scope

   a. Furnish and install all gate valves, plug valves, check valves, butterfly valves, miscellaneous valves, valve boxes and appurtenances required by the plans and this section.

   b. Valves shall be same size as pipeline in which installed, with type joints similar to those in respective pipeline unless otherwise shown; flanges faced and drilled to United States of America standard class 125 pattern; bell and spigot of mechanical joints for class 150 pipe; screwed joints for USA standard threads. Valves shall be factory tested to double working pressure. Working pressure and manufacturer’s name shall be cast on the valve body.

   c. Valves shall be factory tested to twice working pressure. Working pressure and manufacturer’s name shall be cast on the valve body.

2. Submittals

   Shop drawings and certificates of compliance shall be submitted as specified elsewhere herein.

B. MATERIALS

1. Gate Valves

   Gate valves shall be installed at locations shown on the plans. Gate valves shall have a working pressure of not less than 150 psi and shall be iron bodied, bronze mounted, non-rising stems, with resilient seat and shall conform to AWWA Standard Specifications C509.

   All valves inside of structures shall be provided with hand wheel operators.

   Valves outside of structures shall be provided with operating nuts and valve boxes of the telescoping type and of a length to suit the amount of cover.

   Gate valves shall be smaller than 24" and shall be as manufactured by Mueller Company (No. A-2380), M&H, Clow, Dezurik, or approved equal.

2. Plug Valves

   Plug valves shall be of the tight-closing resilient-faced plug type and shall be of eccentric construction such that the opening movement of the closing member (plug) results in the closing member rising off the body seat contact. Port areas
shall be equal to at least 80 percent of the nominal size pipe area. Valves inside structures shall be flanged. Buried plug valves shall be mechanical joint.

Valves shall be drop tight at rated pressure of 150 psi and shall be satisfactory for applications involving throttling service and/or frequent operation and for applications involving open-close valve operation. After long periods of inactivity, the valve closing member (plug) shall rotate approximately 90 degrees from the full-open position to the tight shut position. Fully adjustable stops shall be provided.

Valves shall be equipped with operating nuts and valve boxes of the telescoping type.

Valve bodies shall be constructed of cast iron. The valve body shall be fitted with a bolted bonnet or cover that permits visual examination of the packing without removing operator. The lower trunnion shall be cast integral with the valve body.

The valve plug shall be constructed of cast iron. The plug shall have a cylindrical seat surface which is eccentrically off-set from the center of the plug shafts. The plug shafts shall be integral. The plug shall have a synthetic rubber bonded to all surfaces except shafts and thrust bearing surface.

Valve body seats shall be constructed of a welded-in overlay of not less than 90 percent pure nickel on all body seat surfaces in contact with the plug face.

Valves shall be fitted with sleeve type bearings. Bearings shall be corrosion resistant and constructed of Teflon fiber.

Thrust bearings shall be provided at the top and bottom faced surfaces of the plug. Thrust bearings shall be woven Teflon fiber.

a. Plug Valve Operators

Manual valves shall have lever or worm gear actuators with handwheels, chainwheels, tee wrenches, extension stems, floorstands, etc., as shown on the plans.

Lever actuators shall be furnished for valves 8" or smaller where the maximum shutoff pressure is 25 psi or less as indicated on the plans. Worm gear actuators shall be furnished for all valves 4" or larger where the maximum reverse shutoff pressure is greater than 25 psi as indicated on the plans.

Worm gear actuators shall be sized for pressure as indicated on the plans. All gearing shall be enclosed in a semi-steel housing and be suitable for running in a lubricant with seals provided on all shafts to prevent entry of dirt and water into the actuator. The actuator
shafts and the quadrant shall be supported on permanently lubricated bronze bearings.

Actuators shall clearly indicate valve position and an adjustable stop shall be provided to set closing torque. This adjustable stop shall be the only adjustment necessary to set the clearance between the valve plug and the seat while the valve is in line and under pressure. Handwheel and chainwheel sizes for worm gear actuators shall be no smaller than 6" in diameter and no larger than twice the diameter of the actuator's gear sector. All exposed nuts, bolts, and washers shall be zinc plated.

b. Buried Service

Valves and gear actuators for buried or submerged service shall have seals on all shafts and gaskets on the valve and actuator covers to prevent the entry of water. Actuator mounting brackets for buried or submerged service shall be totally enclosed and shall have gasket seals. All exposed nuts, bolts, springs, and washers shall be stainless steel.

3. Check Valves

a. Swing Check Valves

Swing Check valves shall be counter-weighted, non-slam checks with “O” ring seals designed for working pressure of not less than 150 psi, and shall be similar or equal to heavy duty check valves as manufactured by M&H Company, Mueller Valves Co., Clow Corporation or equal. Check valves larger than 4” shall have weighted external levers.

b. Rubber Flapper Swing Check Valves

Rubber Flapper Check valves shall be manufactured by DeZurik APCO, series 100 Rubber Flapper Swing Check Valve, Val-Matic Model 500A Swing-Flex Check Valve, or an approved equivalent manufacturer and model meeting criteria including but not limited to the following details:

1. The Rubber Flapper Swing Check Valve shall have a heavily constructed cast or ductile iron body and cover. The body shall be long pattern design (not wafer) with integrally cast-on end flanges. The flapper shall be Buna-N having an O-ring seating edge and be internally reinforced with steel.
2. Flapper to be captured between the body and the body cover in a manner to permit the flapper to flex from closed to full open position. Flapper shall be easily removed without the need to remove the valve from line. Check Valves to have full pipe size flow area. Seating surface to be on a 45° angle requiring the flapper to travel only 35° from closed to full open position for minimum head loss, and non-slam closure characteristics.

3. Valve shall be designed for 175 psi differential pressure for sewage applications

4. Provide port and external backflow device to allow prime or backflush of a clogged pump.

5. Provide a Disk Position Indicator device for each valve supplied.

6. Valve shall be serviceable from the top of the valve and allow for disks to be replaced without removal of the entire valve body. Provide one complete rebuild kit as spare parts for each size valve installed.

7. Materials of Construction:
   - Body and Cover:
     - Cast iron: ASTM A126 GR.B
     - Bronze: ASTM 584
     - Stainless steel: ASTM A296 or 351
     - Ductile iron: ASTM A536 Gr.65-45-12
     - Flapper: Buna-N or other elastomers
     - Exterior paint: Universal Metal Primer

4. Butterfly Valves

Butterfly valves shall be manufactured in accordance with the latest revision of AWWA C504, Class 150B and conform to NSF Standard 61. The manufacturer shall have produced AWWA butterfly valves for a minimum of five years. Butterfly valves shall be manufactured by Mueller, Pratt or equal.

a. Valve Body. Valve bodies shall be constructed of ASTM A126, Class B cast iron for flanged valves. Flanged valves shall be fully faced and drilled in accordance with ANSI Standard B16.1, Class 125. Laying length and minimum body thickness shall be in accordance with AWWA C504.

b. Valve Seats
1. Bonded Seat (Valves 3” – 20”): Rubber body seats shall be of one piece construction, simultaneously molded and bonded into a recessed cavity in the valve body. Seats may not be located on the disc or be retained by segments and/or screws.

2. Mechanical Seat (Valves 24” and larger): Mechanical seats shall be constructed of Buna-N rubber and suitable for bidirectional shutoff at rated pressure. Seats shall be retained in the valve body by mechanical means without retaining rings, segments, screws or hardware of any kind in the flow stream. Seats shall be a full 360 degrees circumference and replaceable without dismantling actuator, disc or shaft and without removing valve from the line.

c. **Valve Bearings.** Valve bearings shall be of a self-lubricating, nonmetallic material to effectively isolate the disc-shaft assembly from the valve body. Metal-to-metal thrust bearings in the flow stream are not allowed.

d. **Valve Disk.** 3” thru 24” disc shall be a lens-shaped design and 30” and larger flow-through design to afford minimal pressure drop and line turbulence.

1. Materials of construction shall be:
   - 3”-6” — ASTM A351 gr. CF8M stainless steel disc
   - 8”-20” — ASTM A126, Class B cast iron disc with a stainless steel type 316 edge
   - 24” and larger — ASTM A536 (65-45-12) ductile iron disc with a stainless steel type 316 edge

Discs shall be retained by stainless steel pins which extend through the full diameter of the shaft to withstand the specified line pressure up to valve rating and the torque required to operate the valve. Disc stops located in the flow stream are not allowed.

e. **Valve Shafts.** Valve shafts shall be of stainless steel type 304. At the operator end of the valve shaft, a shaft seal utilizing “V” type chevron packing shall be utilized. “O” ring and/or “u” cup packing is not allowed. For 24” and larger, shafts shall be two-piece, stub-type and keyed for actuator connection. Shaft diameters shall meet minimum requirements established by the latest revision of AWWA Standard C504 for their class, where applicable. Shaft seals shall be of a design allowing replacement without removing the valve shaft.

5. **Valve Accessories**
a. **Valve Boxes.** Cast iron extension type, of suitable length and diameter for individual location, complete with removable cast iron cover. Minimum 3/16-inch thickness of metal at any point. Factory painted inside and out with good quality asphalt paint. Boxes shall be installed on all underground valves, with top flush with or slightly above ground surface.

b. **Extension Stems.** Standard extension stem of dimensions required to extend valve stem to required elevation; designed to operate respective valve; complete with coupling and operating nut. Extension stems for underground valves equipped with valve boxes shall be of such length as to extend within 18 to 24 inches from top of valve box and shall be provided with washers or centering plates to facilitate use of operating wrenches.

6. **Valve Painting**

a. All surfaces of the valve interior shall be clean, dry and free from grease before painting. The valve interior and exterior shall be evenly coated with an NSF61 approved 2-part liquid epoxy. Minimum dry film thickness shall be 8 Mils minimum.

7. **Electric Motor Operators**

a. Where indicated on drawings provide an electric motor operator of the close-coupled, electric motor-driven, worm gear type, complete with motor, gearing, limit switches and auxiliary contacts, torque switches, hand wheel, integral controller, and all required appurtenances. Electric motor operator shall be capable of continuous modulating service.

b. Electric motor operators and controls located in classified areas shall be explosion proof design and capable of being certified for use in Class 1, Groups C & D hazardous locations by either Factory Mutual (F.M.) or Underwriters Laboratories (U.L).

c. The operator shall be mounted in the position as shown on the plans.

d. The motor operators must meet AWWA C540 standards.

e. The operator shall be designed for outdoor operation and for an ambient temperature range of -20 to 140 degrees F.

f. The operator shall be designed to exert an unseating torque of at least 50 percent in excess of the required disc seating torque at the specified voltage, neglecting hammer-blow effect.

g. The power gearing shall consist of helical or spur gears and worming gear.
The helical and spur gears shall be accurately fabricated of machined alloy steel. The hardened alloy steel worm gear shall have the threads ground and polished after heat treating. Worm gear may be constructed of nickel or manganese bronze. Antifriction bearings shall be utilized throughout. The operator may be lubricated by grease pack or oil bath. The lubricants provided shall be suitable for the ambient temperatures specified.

h. A handwheel for manual operation shall be provided and shall have a maximum rim pull of 40 pounds. The handwheel shall be designed so that it does not rotate during electrical operation and the motor does not rotate during manual handwheel operation. The operator shall be designed so that motor or motor gearing failure does not prevent manual operation. The operator shall be automatically change from manual operation to electrical operation when the motor is energized and to continue electric operation until the operator is reset to manual operation. A means for locking the drive in either manual or motor operation shall be provided. The handwheel shall be removable. An adapter key or drive nut shall be provided to permit operation by a portable operator. A declutching mechanism shall be provided to disengage the motor mechanically by not electrically from motor to handwheel operation. If the clutch is of the external lever type, arrange it such that the lever does not move when the motor is energized.

i. The operator motor shall be of the high torque, ball or roller bearing, squirrel-cage type designed for continuous valve duty. The motor shall be rated for 15 minute duty cycle or three complete opening and closing valve strokes, whichever is longer, during a 60 minute period under full differential pressure at 40 degrees C ambient. The motor shall operate on 120 volts, 1-phase, 60-hertz electrical service. The motor windings and leads shall have Class F or better insulation with built-in thermal overload protection.

j. The housing for the controls, gears, and motors shall be provided with integrally cast flanges. The flanges and mating surfaces shall be fully machined and template drilled. The joints shall be metal-to-metal or gasket or O-ring sealed as required.

k. The control and motor enclosures shall be NEMA 4 rated, except as otherwise specified. The controller shall be provided with mechanical interlocks and mounted as an integral part of the operator. For explosion-proof enclosures which are dependent upon metal-to-metal faces for weatherproofing, include explosion-proof breathers and drains with desiccant type dehumidification and with sufficient silica gel desiccant for 6 months service without requiring renewal. Instructions for desiccant renewal shall be provided.

l. The electrical controls for the operators shall be as shown and specified.
The operators shall be designed for 460-volt, 3-phase, 60-hertz service. All control circuits shall be designed for 120-volt, single phase, 60-hertz service.

m. A NEMA rated reversing controller, or an approved special duty rated reversing controller, complete with mechanical interlocks and controls as an integral part of the operator shall be provided. Adequate overload protection in the controller or embedded in the motor windings shall be provided. An overload device shall be installed in each phase. If the overload devices are installed in the motor windings, devices of the bimetallic automatic reset type with contact in the control circuit shall be provided. The internal wiring in the operator shall be arranged so that the opening and closing coils cannot be energized simultaneously at any time, regardless of external wiring conditions.

n. The OPEN-STOP-CLOSE push buttons or a selector switch shall be mounted on the operator housing, as shown. The red and green position indicator lights and where shown the amber ready light or MANUAL-AUTO mode selector switch shall be mounted on the operator housing.

o. The operator shall be provided with limit and torque switches, either direct or gear driven. The limit and torque switches shall be adjustable with auxiliary contacts that are operative in either direction of travel. The limit switches shall be “in-step” with the torque switches at all times, whether in motor or manual operation. The operator shall be equipped with limit switches to stop movement in each direction and torque switches for protection against mechanical overload and to stop movement in either direction if an obstruction is encountered. The number, function, and arrangement of the limit switches shall be provided as shown, specified, or required.

p. Additional limit switches, indicating lights, position transmitters and remote position indicators, remote operating controls and other accessories and controls shall be provided where shown, specified, or required.

q. The electric motor actuators shall be M2CP multi-turn as manufactured by Emerson Process Management (formerly EIM), or equal.

END OF SECTION
PART 1 - GENERAL

1.1 SUMMARY

A. This section of the specification describes the sewage grinder(s) and motor controller(s). The equipment shall be installed as shown on the plans, as recommended by the supplier, and in compliance with all OSHA, local, state and federal codes and regulations.

B. The number of grinder(s) and motor controller(s) shall be one (1).

C. The grinder shall be capable of processing 9,800 GPM with a maximum headloss of 18 inches with an unrestricted discharge.

1.2 REFERENCES

A. Grinder(s) shall, as applicable, meet the requirements of the following industry standards:


3. American Iron and Steel Institute (AISI) 303 Stainless Steel

4. American Iron and Steel Institute (AISI) 304 Stainless Steel

5. American Iron and Steel Institute (AISI) 4130 Heat Treated Alloy Steel

6. American Iron and Steel Institute (AISI) 4140 Heat Treated Hexagon Steel

7. Rockwell C

B. Motor controllers shall, as applicable, meet the requirements of the following Regulatory Agencies.

1. National Electrical Manufacturer's Association (NEMA) Standards

2. National Electrical Code (NEC)

3. Underwriters Laboratory (UL and cUL)
1.3 DOCUMENTS

A. Shop Drawing(s)

Supplier shall submit six (6) set(s) of shop drawings. Shop drawings shall include equipment descriptions, specifications, dimensional and assembly drawings, parts lists, and job specific drawings.

B. Operation and Maintenance Manuals

Supplier shall submit three (5) set(s) of Operation and Maintenance manuals prepared using best commercial practices. The manuals shall include equipment descriptions, operating instructions, drawings, troubleshooting techniques, a recommended maintenance schedule, and the recommended lubricants.

1.4 QUALITY ASSURANCE

Qualified suppliers shall have a minimum 25 years experience at manufacturing, support systems, two-shafted grinding equipment and motor controls with a minimum of 5,000 installations with similar equipment. Supplier shall provide a list of names and dates of installations for verification by the Engineer or Owner's Representative.

Supplier shall provide the services of a factory-trained representative to check the installation and to start-up each grinder and controller. The factory representative shall have complete knowledge of proper installation, operation, and maintenance of equipment supplied. Representative shall inspect the final installation and supervise a start-up test of the equipment.

Each grinder and controller shall be factory tested to ensure satisfactory operation.

1.5 DELIVERY, STORAGE AND HANDLING

A. The equipment shall be packaged in containers constructed for normal shipping, handling and storage.

B. The containers shall provide adequate protection for the equipment in a dry indoor environment between +40°F (+4.5°C) and +100°F (+37.8°C) until time for installation.

1.6 IDENTIFICATION

Each unit of equipment shall be identified with a corrosion resistant nameplate, securely affixed in a conspicuous place. Nameplate information shall include equipment model number, serial number, supplier's name, and location.
PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Support system(s), grinder(s), and motor controller(s) shall be in compliance with these specifications and plans and shall be supplied by one of the following manufacturers:

1. JWC Environmental® Channel Monster® grinder model No. CDD4020-XDS2.0 with Severe Duty Cutters and Monster Metal Stack.

2. Approved equal

B. Manufacturers requesting to be selected as an approved equal shall submit certified documentation showing compliance with these specifications a minimum of ten (10) days prior to bid opening. Selected equipment manufacturers shall be added to the list of approved manufacturers.

C. The manufacturer must certify that the unit can be returned for maintenance to the factory or a local repair facility. The certification shall include a statement that there will be no charge for repair labor.

2.2 SUPPORT SYSTEM(S)

A. GENERAL

A grinder support frame with adjustable mounting brackets shall be provided for a 36” circular pipe. Support frame shall be designed to operate with a retrievable rail system to be supplied by the equipment manufacturer. Refer to construction drawings for details.

B. COMPONENTS

The support frame, additional supports and retrievable rail system shall be of welded square tube, angle, and plate construction. The construction material shall be 316 stainless steel.

2.3 GRINDER(S)

A. GENERAL

1. Each grinder shall include cutters, spacers, shafts, 10 inch (254 mm) diameter coil screen drum, bearings and seals, side rails, end housings, covers, reducer, and motor.

2. The grinder shall be of two (2)-shaft design and be capable of continuous
operation, processing wet or dry. Bar screens or single-shaft devices utilizing a single rotating cutter bar with stationary cutters shall not be acceptable. Grinders designed with cutter and spacer cartridges rather than individual cutters and spacers, shall not be acceptable.

3. Two (2)-shaft design shall consist of two (2) parallel shafts alternately stacked with individual intermeshing cutters and spacers positioned on the shaft to form a helical pattern. The two (2) shafts shall counter-rotate with the driven shaft operating at approximately two-thirds (2/3) the speed of the drive shaft.

4. The ten (10) inch (254-mm) diameter rotating coil screen drum shall consist of a helical coil mounted to vertical supports and stub shafts. The rotating drum shall direct all solids toward and into the counter-rotating dual-shaft grinder. The drum shall be driven by the grinder drive mechanism.

B. COMPONENTS

1. Individual Cutters and Spacers
   a. The cutting chamber shall be a nominal height of 44-1/2” inches (1130 mm).
   b. Individual cutters and spacers shall be 4130 heat treated alloy steel, surface ground for uniformity and through-hardened to a minimum 45-50 Rockwell C.
   c. The inside configuration of both the individual cutters and the individual spacers shall be hexagonal so as to fit the shafts with a total clearance not to exceed 0.015 inch (0.38 mm) across the flats to assure positive drive, minimize wear on the cutters.
   d. Cutter configuration shall consist of individual 11 tooth cam cutters on both shafts. To maintain particle size, the height of the tooth shall not exceed 1/2 inch (13 mm) above the root diameter. Cutter to cutter root diameter overlap shall be not less than 1/16 inch (1.6 mm) or greater than 1/4 inch (6 mm) to maintain the best possible cutting efficiency while incurring the least amount of frictional losses.
   e. The cutters shall exert a minimum force at the tooth tip of 2051 lbs/hp (12,234 N/kW) during momentary load peaks.

2. Shafts
a. Grinder drive and driven shafts shall be made of 4140 heat treated hexagon steel with a tensile strength rating of not less than 149,000 psi (1,027 kPa).

b. Each hexagonal shaft shall measure a nominal 2 inches (51 mm) across parallel surfaces.

3 Coil Screen Drum

a. The 10 inch (254 mm) diameter coil screen drum shall be made of coil-wound 304 stainless steel rod. The coil shall be ½-inch (13 mm) diameter AISI 304 stainless steel with ½-inch (13 mm) spacing between coils.

b. The drum support skeleton shall be constructed of 304 stainless steel. The support skeleton shall include hubs for mounting of drum stub shafts. Vertical members shall provide support for the coil.

c. Drum stub shafts shall be made of 304 stainless steel with a tensile strength of not less than 95,000 psi (654,550 kPa). The shaft diameter shall be a minimum of 1-1/2 inch (38 mm).

4. Shaft Bearings and Seals

a. The radial and axial loads of the cutter shafts and coil drum stub shafts shall be borne by sealed, oversized, deep-groove ball bearings at each end.

b. The bearings shall be protected by a combination of a replaceable and independent tortuous path device and mechanical seals.

c. Face materials shall be of tungsten carbide to tungsten carbide.

d. O-rings shall be made of Buna-N elastomers.

e. Products requiring continuous or occasional lubrication or flushing shall not be accepted.

f. The mechanical seal shall be rated at 90 psi (620 kPa) continuous duty by the seal supplier.

g. The bearings shall be housed in a replaceable cartridge that supports and aligns the bearings and seals, as well as protects the shafts and end housings. The seal elements shall be independent of the stack height, therefore cutter stack tightness shall not affect
seal performance. The seal elements shall maintain their factory set preload independent of the cutter stack tightness.

h. Seals shall meet required pressure rating regardless of cutter stack fit. The seal cartridge shall provide seal protection against axial loading on shafts and bearings during shaft deflection.

i. Each seal element shall be positively locked to its corresponding rotating or static cartridge element. This positive lock on the seal elements is critical to long seal life in applications where grit or other abrasive materials are present.

5. Cutter Side Rail

   a. The inside profile of the cutter side rail shall be concave to follow the radial arc of the cutters.

   b. Clearance between the major diameter of the cutter and the concave arc of the side rail shall not exceed 5/16 inch (7.9 mm).

   c. The cutter side rail shall have evenly-spaced slots that increase flow and decrease head loss.

   d. The cutter side rail shall be cast of A536-84 ductile iron.

6. Drum Side Rail

   a. The inside profile of the drum side rail shall be concave, with an adjustable UHMW plastic extension strip to minimize clearance at the front of the drum. This clearance shall not exceed 1/16 inch (1.6 mm) from the major diameter of the coil screen drum.

   b. The drum side rail shall be cast of A536-84 ductile iron.

7. End Housings and Covers

   a. Grinder end housings shall be of cast A536-84 ductile iron with a cast-in-place flow deflector, designed to protect the bushings while guiding particles directly into the cutting chamber.

   b. Top covers shall be A536-84 ductile iron and bottom covers shall be A36 hot rolled plates.

8. Reducer

   a. The speed reducer shall be a grease-filled planetary-type of reducer
with a 500% shock load capacity. The reduction ratio shall be 29:1.

b. The input shaft of the reducer shall be directly coupled to the motor using a three-piece coupling, and the output shaft of the reducer shall be directly coupled with the grinder using a two-piece coupling.

9. Immersible Motor
   a. The motor shall be 10 hp, Immersible XPNV, 1770 rpm, 230/460 volt, 3 phase, 60 Hz, class F insulation.
   b. Motor service factor shall be 1.15, the efficiency factor not less than 91% at full load and the power factor not less than 76% at full load.
   c. Motor shall have a casing surface temperature no greater than 1850 F (850 C) at an ambient temperature of 860 F (300 C). Others wishing to be approved as equals shall conduct an on site test no more than 10 days after installation demonstrating compliance with temperature specification.
   e. Motors utilizing oil filled chambers to lubricate seals shall not be acceptable.

2.4 MOTOR CONTROLLER(S)

A. GENERAL
   1. The controller shall provide independent control of the grinder.
   2. Controller shall be the City of Tulsa standard UL/cUL listed Model PC2200.
   3. The controller shall be rated for 10 hp (3.75 kW), 460 volts, 3 phase, 60Hz.
   4. The controller shall incorporate a phase monitor (Timemark C2644) with fused disconnect switch integral to the control panel. Provide a normally open contact from the phase monitor in parallel with the e-stop button. Provide a dry contact from the HOA switch (open in OFF position, closed in AUTO or HAND position). Provide 30 mm LED pilot lights for
POWER, RUN, FAIL. Flash indicator – Grinder jammed, solid light – overload tripped, Long on Short off – over temp. PLC shall be Allen-Bradley Micrologics 1000. General purpose relay shall be IDEC RHUBL series.

B. OPERATION

1. The controller shall be equipped with a GRINDER ON-OFF/RESET-REMOTE three (3) position selector switch.
   
a. In the ON position the grinder will run.
   
b. In the OFF/RESET position grinder shall not run.
   
c. In the REMOTE position the grinder shall start and stop as controlled by a remotely-located dry contact.
   
d. The grinder shall only be reset by switching the GRINDER ON-OFF/RESET-REMOTE switch to the OFF/RESET position.

2. The controller shall also be equipped with a push button allowing for momentary reverse of the cutter stacks. Reverse operation shall only initiate while button is depressed and shall cease when button is released. The controller shall not allow for constant reverse operation and the hand-off-auto switch in the off position.

C. COMPONENTS

1. Enclosure
   
a. Enclosures shall be NEMA 4X, fabricated of fiberglass-reinforced polyester resins, and shall be suitable for wall mounting. Doors shall have corrosion-resistant hinges and latches.
   
b. Enclosure shall house the control devices, relays, terminal blocks and reversing motor starters.

2. Control Devices
   
a. Pilot devices shall be mounted on the enclosure front panel door.
   
b. The controller shall have 30 mm L.E.D. indicator lights for POWER ON, RUN, and FAIL.
   
c. Indicator lights shall be 30 mm L.E.D. type pilot lights. Lights and selector switches shall be heavy duty NEMA 4X type.
d. Control transformer shall be protected by two primary fuses and one secondary fuse. The 120 volt secondary shall have one leg grounded.

e. Relay contacts shall be included for GRINDER run and FAIL signal outputs. The contacts shall be rated 2 ampere, 240 VAC, resistive load.

3. Motor Starter

a. Starter shall be a full-voltage, NEMA Rated SQ.D reversing type with 120 volt operating coils.

b. Forward and reverse contactors on the starters shall have both mechanical and electrical interlocks.

c. Overload relays (OL) shall be adjustable so that the range selected includes the FLA (full load amperes) rating and service factor.

d. All motor starters, indicator lights, H.O.A. switches, reset buttons, and overload units shall be Square-D.

D. SAFETY FEATURES

1. When a grinder jam condition occurs in the grinder ON or REMOTE mode the controller shall stop the grinder, then reverse the grinder rotation to clear the obstruction. If the jam is cleared, the controller shall return the grinder to normal operation. Up to two (2) additional reversing cycles (3 times total) may occur within 30 seconds before the controller de-energizes the grinder motor and activates the grinder fail indicator and relay.

2. If a power failure occurs while a grinder is running, operation will resume when power is restored.

3. If a power failure occurs while the grinder is in a fail condition the fail indicator shall reactivate when power is restored.

4. The controller shall provide overload protection for the motor through an overload relay mounted directly on the grinder starter with isolated N.O. contact that close when overload trips. All overload units shall be resettable from the panel front.

5. Provide short-circuit protection in the panel with a properly-sized Square-D circuit breaker and a throttle door operator.
6. Controller reset shall be from the local panel controls only.

PART 3 - EXECUTION

3.1 INSTALLATION

Grinder(s) and motor controller(s) shall be installed in accordance with the supplier’s installation instructions, and in compliance with all OSHA, local, state, and federal codes and regulations.

3.2 MANUFACTURER'S SERVICES

A. The Contractor shall require the manufacturer to furnish the services of a qualified field engineer to perform the following functions in the designed periods of time. These services are to be performed at the jobsite. A minimum of one (1) visit to the job site totaling a minimum of four (4) hours shall be required or necessary visits to inspect and certify installed equipment.

1. Check-out of installation, start-up of equipment and initial operator instruction. This service shall take place after all mechanical equipment and the control system is installed and mechanically operable.

2. After equipment is fully operational, and before Owner will assume responsibility for the operation of the equipment, the equipment manufacturer's representative shall instruct the Owner's operating personnel in the care, maintenance and proper operation of the equipment.

END OF SECTION
PART 1 GENERAL

1.01 SCOPE OF WORK

A. The Contractor shall procure the services of a single System Integrator to furnish all materials, equipment, labor and services, required to achieve a fully integrated and operational system as specified herein and in other Specification Sections listed below.

B. Auxiliary and accessory devices necessary for system operation or performance, such as transducers, relays, signal amplifiers, intrinsic safety barriers, and signal isolators, to interface with existing equipment or equipment provided by others under other Sections of these specifications, shall be included whether they are shown on the Drawings or not.

C. Substitutions on functions or type of equipment specified shall not be acceptable unless specifically noted. In order to confirm compatibility between all equipment, coordinate all interface requirements with mechanical and electrical systems and furnish any signal isolation devices that might be required.

D. Equipment shall be fabricated, assembled, installed and placed in operating condition in full conformity with the project Specifications, Drawings, engineering data, instructions, and recommendations of the equipment manufacturer as approved by the Engineer.

E. To facilitate the Owner's future operation and maintenance, similar products (e.g., differential pressure transmitters, SCADA I/O cards) shall be supplied from the same manufacturer.

F. All equipment and installations shall satisfy applicable Federal, State and local codes.

1.02 QUALITY ASSURANCE

A. The System Integrator shall be regularly engaged in the design and the installation of instrumentation systems and their associated subsystems as they are applied to the municipal water and wastewater industry.

1.03 NOMENCLATURE AND IDENTIFICATION

A. Field Instrument Tags

1. A permanent stainless steel or other non-corroosive material tag firmly attached and permanently and indelibly marked with the instrument tag number, as indicated in the Drawings, shall be provided on each piece of equipment supplied under this Section. Equipment shall be tagged before shipping to the site.

2. Provide 1/8-in by 3/8-in, Type 316 stainless steel button head machine screws.

3. All supplied field instrument transmitters and field instrument transmitter elements shall have a stainless steel identification tag attached to each transmitter and element prior to shipment. Tag shall be attached via stainless steel chain or stainless steel wire (24 gauge min) to a non-removable part of the device. The tag size shall be a minimum of 1.5 square inches. Tag shall include the ISA alphanumeric instrument
number as indicated in the P&ID, loop, and detail drawings. The alphanumeric instrument number shall be stamped into the tag and shall have a minimum of 3/16-in high alphanumeric characters.

1.04 PROJECT/SITE REQUIREMENTS

A. Temperature:
   1. Outdoor areas' equipment shall operate between -30 to 50 C degrees ambient.
   2. Equipment located in indoor locations shall operate between 10 to 35 C degrees ambient minimum.
   3. Storage temperatures shall range from 0 to 50 C degrees ambient minimum.
   4. Additional cooling or heating shall be furnished if required by the equipment as specified herein.

B. Relative Humidity. Air conditioned area equipment shall operate between 20 to 95 percent relative, non-condensing humidity. All other equipment shall operate between 0 to 100 percent relative, condensing humidity.

PART 2 PRODUCTS

2.01 PRODUCTS GENERAL

A. All instrumentation and electronic equipment shall be of the manufacturer's latest design, utilizing printed circuitry and epoxy or equal coating to prevent contamination by dust, moisture and fungus. The field mounted equipment and system components shall be designed for installation in dusty, humid and slightly corrosive service conditions.

B. All instruments shall be provided with mounting hardware and floor stands, wall brackets, or instrument racks unless otherwise noted. Fasteners for securing control panels and enclosures to walls and floors shall be either hot-dipped galvanized after fabrication or stainless steel.

C. All indicators shall be linear in process units, unless otherwise noted. All transmitters shall be provided with indicators in process units, accurate to two percent or better.

D. All equipment, cabinets and devices furnished shall be heavy-duty type, designed for continuous industrial service. The system shall contain similar products of a single manufacturer, and shall consist of equipment models, which are currently in production. All equipment provided shall be of modular construction and shall be capable of field expansion.

E. All electronic/digital equipment shall be provided with radio frequency interference protection.

F. Electrical
   1. Equipment shall operate on a 60 Hertz alternating current power source at a nominal
120 volts, plus or minus 10 percent, except where specifically noted. Regulators and power supplies required for compliance with the above shall be provided between power supply and interconnected instrument loop. Where equipment requires voltage regulation, constant voltage transformers shall be supplied.

2. With the exception for field device network connected devices, all electronic instrumentation shall utilize linear transmission signals of isolated 4 to 20 mA DC (milliampere direct current) capable of driving a load up to 750 ohms, unless specified otherwise. However, signals between instruments within the same panel or cabinet may be 1-5 VDC (volts direct current).

3. Outputs of equipment that are not of the standard signals as outlined, shall have the output immediately raised and/or converted to compatible standard signals for remote transmission. No zero based signals will be allowed.

4. All switches shall have double-pole double-throw contacts rated at a minimum of 600 VA, unless noted otherwise.

5. Switches and/or signals indicating an alarm, failure or upset condition shall be wired fail-safe to the SCADA system. A fail-safe condition is an open circuit when in an alarm state.

6. Materials and equipment shall be UL approved. Where components are not available with UL approval, integrate the device with ground fault protective devices, isolation transformers, fuses, or other protective equipment necessary to achieve compliance with UL 508 requirements.

7. Equipment shall be constructed so that when a power interruption occurs, the equipment specified hereunder resumes normal operation without manual resetting when power is restored unless otherwise noted.

8. All transmitter output signals shall include signal and power source isolation.

2.02 LIGHTNING/SURGE PROTECTION

A. General - Lightning/Surge protection shall be provided to protect the electronic instrumentation system from induced surges propagating along the signal and power supply lines from lightning, utility, or the internal plant electrical distribution system. The protection systems shall be such that the protective level shall not interfere with normal operation, but shall be lower than the instrument surge withstand level. Protection shall be maintenance free and self-restoring. Ground wires for all instrumentation device surge protectors shall be connected to a good earth ground.

B. Field Instrumentation Protection - Provide individual device protection for the 4-20 mA signal and, if 4 wire field instrument, the power supply of each field instrument mounted outside of the building or facility housing the control panel. Instruments mounted within the structure as the associated control panel shall not require surge protection. Instruments shall be housed in a grounded metallic case. Device surge protectors shall be mounted within the instrument enclosure or a separate junction box coupled to the enclosure. Provide gas tube or metal oxide varisters (MOV) surge protection devices as manufactured by Phoenix Contact, EDCO, Emerson Network Power Control Concepts,
or equal.

C. Control Panel Power Feed – Provide protection of all 120 VAC power feeds into the control panels. Source voltage to cabinets/panels regardless of location (indoor or outdoor), shall be protected by isolation transformers and surge suppressors. Provide gas tube surge suppressors or metal oxide varisters (MOV's) located at the point where the 120V source supply enters the enclosure. Install the surge device to in strict compliance with the manufacturer's recommendation for maximum allowable circuit length between protective device and incoming circuit. Provide signal surge suppression devices as manufactured by Phoenix Contact, EDCO, Emerson Network Power Control Concepts, or equal.

D. 4-20 mA Signal Lines and Non-Fiber Based Data Highway Circuits – Provide protection on all signal and data highway circuits that leave a building or are routed external to a building. Provide gas tube surge arrestors, and Zener diode protectors. Circuit protection shall be provided at both ends of the signal or data highway lines within the control panel at one end and as close to the instruments or termination device as possible. Provide signal surge suppression devices as manufactured by Phoenix Contact, EDCO, Emerson Network Power Control Concepts, or equal.

E. Inductive Loads – At a minimum, provide coil surge suppression devices, such as varistors, or interposing relays on all process controller outputs or switches rated 120 VA or less that drive solenoid, coil, or motor loads.

F. Telephone Circuits - At a minimum, provide Telephone Company approved line protection units for all telephone lines used for telemetry or SCADA system use under this Contract.

2.03 SPARE PARTS

A. Spare parts of the type and quantity as recommended by the manufacturer shall be furnished for all devices furnished under these sections.

B. All spare parts shall be wrapped in bubble wrap, sealed in a polyethylene bag complete with dehumidifier, then packed in cartons and labeled with indelible markings. Complete ordering information including manufacturer's part number, part ordering information including manufacturer, part number, part name, and equipment name and number(s) for which the part is to be used shall be supplied with the required spare parts. The spare parts shall be delivered and stored in a location directed by the Engineer.

C. As a minimum, furnish the following spare parts for control panels:

1. Timers - Five of each type installed.

2. Relays - Five of each type installed.

3. Fuses and circuit breakers - 10% (minimum of 10 fuses and 2 circuit breakers) of each type and size installed.

4. Light bulbs - 10% (minimum of 10) of each type installed.
5. Power supplies - one of each type installed.
6. Manufacturer's cables - one of each type installed.
7. Selector switches/pushbuttons - Two of each type installed including 5 contact blocks.
8. Surge protection devices - One of each type installed.
9. Provide one quart of touch-up paint, for each type and color used for all RTU cabinets, panels, and consoles supplied.

D. PLC components
1. One spare CPU of each type supplied
2. Two spare I/O modules of each type supplied
3. One spare specialty interface module of each type supplied
4. One spare remote I/O communication module of each type supplied
5. One spare communications module of each type supplied.
6. One spare power supply of each type supplied
7. One spare type of each communication cable supplied

PART 3 EXECUTION

3.01 GENERAL INSTALLATION

A. Instrumentation and accessory equipment shall be installed in accordance with the manufacturer's instructions. The locations of equipment, transmitters, alarms and similar devices indicated are approximate only. Exact locations of all devices shall be as approved by the Engineer during construction. Obtain in the field, all information relevant to the placing of process control equipment and in case of any interference with other work, proceed as directed by the Contractor and furnish all labor and materials necessary to complete the work in an approved manner at no additional cost to the Owner.

B. The P&IDs and Drawings indicate the intent and not the precise nature of the interconnection between the individual instruments. Where indicated on the P&IDs or Drawings as not requiring installation, provide the instruments suitably packaged for storage.

C. Unless specifically indicated, direct reading or electrical transmitting instrumentation shall not be mounted on process piping. Instrumentation shall be mounted on instrument racks or stands. All instrumentation connections shall be provided with shutoff and drain valves. For differential pressure transmitters, 5-valve manifolds for calibration, testing and blow down service shall also be provided. For chemical or corrosive fluids,
diaphragm seals with flushing connections shall be provided.

D. All piping and tubing to and from field instrumentation shall be provided with necessary unions, calibrations and test tees, couplings, adaptors, and shut-off valves. Process tubing shall be installed to slope from the instrument toward process for gas measurement service and from the process toward the instrument for liquid measurement service. Provide drain/vent valves or fittings at any process tubing points where the required slopes cannot be maintained.

E. Brackets and hangers required for mounting of equipment shall be provided. They shall be installed as shown and not interfere with any other equipment.

F. The shield on each process instrumentation cable shall be continuous from source to destination and be grounded at only one ground point for each shield.

G. Installation of fiber optic cable within control panel and console assemblies. Refer to cable manufacturer's specifications for bend radius. Use cable breakout assembly as recommended by the cable manufacturer. Provide wire basket, strain relief as required to meet manufacturer's strain requirements.

H. Provide local electrical shutoffs and disconnects for all 4-wire field instruments requiring 120 VAC power. Electrical disconnects shall be suitably rated disconnect switches or manual motor starters as specified under Division 16.

I. Provide sunshades for equipment mounted outdoors in direct sunlight. Sunshades shall include standoffs to allow air circulation around the cabinet. Orient equipment outdoors to face to the North or as required to minimize the impact of glare on LED, LCD, or other digital readouts.

1. Loop Tuning - All electronic control stations incorporating PID controllers shall be tuned following device installation but prior to commencement of the field tests.

2. Optimal loop tuning shall be achieved either by auto-tuning software or manually by trial and error, Ziegler-Nichols step-response method, or other documented process tuning method. Assigning common PID factors for identical loops following field tuning of a single typical loop is acceptable

3. Determine and configure optimal tuning parameters to assure stable, steady state operation of final control elements running under the control of field mounted, dedicated PID controllers or software based PID controllers residing as part of the programmable logic controller system. Each control loop that includes anti-reset windup features shall be adjusted to provide optimum response following startup from an integral action saturation condition.

4. Tune all PID control loops to eliminate excessive oscillating final control elements. Loop parameters shall be adjusted to achieve 1/4 amplitude damping or better. In addition, loop steady state shall be achieved at least as fast as the loop response time associated with critical damping.

5. Loop performance and stability shall be verified in the field following tuning by step changes to setpoint. Submit loop tuning methodology and verification as part of the
final system documentation as specified in Part 1.

6. For cascade loops, tune both sets of controllers so that the cascade loop achieves the loop tuning characteristics specified herein.

END OF SECTION
PART 1 GENERAL

1.1 SCOPE OF WORK

A. This Section includes Programmable logic controllers for control of process equipment, process oriented machinery, and process systems.

1.2 QUALITY ASSURANCE

A. Manufacturer Qualifications: A qualified manufacturer shall be capable of providing training, parts, and coordination of emergency maintenance and repairs.

B. The programmable controller and all of the corresponding components within the family of controller products shall be manufactured by a company who regularly manufactures services this type of equipment.

C. The manufacturer shall comply with ISO9001 standards for "Quality Systems- Model for Quality Assurance in Design/Development, Production, Installation, and Servicing".

D. The manufacturer shall provide complete technical support for all of the products. This shall include factory on-site training, regional application centers, local or factory technical assistance, and a 24/7/365 technical support phone service.

1.3 DELIVERY, STORAGE, AND HANDLING

A. Deliver PLC components in packaging designed to prevent damage from static electricity and physical damage.

B. Store PLC equipment according to manufacturer requirements. At a minimum, store indoors in clean, dry space with uniform temperature to prevent condensation. Protect PLCs from exposure to dirt, fumes, water, corrosive substances, and physical damage. Also, protect the PLC from all forms of electrical and magnetic energy that could reasonably cause damage.

1.4 NOMENCLATURE AND IDENTIFICATION DEFINITIONS

A. AI: Analog Input

B. AO: Analog Output

C. Fixed I/O: A PLC style consisting of a fixed number of I/O, a processor, and a power supply all in one enclosure. Some fixed PLCs have limited expansion ability.

D. CPU: Central Processing Unit

E. DI: Discrete Input

F. Distributed I/O: Hardware specially designed to function as Remote I/O.

G. DO: Discrete Output
H. HMI: Human-Machine Interface

I. I/O Input and/or Output

J. Modular: A PLC style consisting of cards that are assembled to comprise a complete unit. All I/O, CPU, and Power Supply are dedicated cards. Typically, these cards are inserted into a chassis.

K. Master/Slave: Communication between devices in which one device, the master, controls all communications. The other devices, the slaves, respond only when queried by the master. Typically used in a Remote I/O application.

L. Peer to Peer: Communication between two or more devices, typically PLC’s, in which each device can control the communication exchange.

M. PID: Control action, proportional plus integral plus derivative.

N. PLC: Programmable Logic Controller

O. Remote I/O: I/O that is located remotely from the processor. Remote I/O can communicate over a variety of communication protocols and can use standard rack based I/O, or special Remote I/O hardware referred to as Distributed I/O.

P. SCADA: Supervisory Control and Data Acquisition

1.5 SPARE PARTS

A. Supply spare parts equal to the greater of 25 percent or one field-replaceable system components unless noted otherwise.

B. At a minimum, provide the following:

1. Processors: Provide spare processor unit(s) for each unique processor installed.

2. Memory Cards: Provide spares for each type of card installed.

3. I/O Cards: Provide spares for each unique I/O module type installed. Provide two or 25 percent of installed quantity, whichever is greater.

4. Network interface and communication modules: Provide spare communication modules for each unique communication module installed.

5. Specialty Modules: Provide as a minimum a spare of each type of module identified

6. PLC Power supplies: Provide spare power supplies for each unique power supply installed.

7. Chassis: Provide spare chassis for each unique chassis installed.

8. Fixed PLCs: Provide spares for each unique type of PLC installed.

9. Miscellaneous components (including cables): Provide spares for each unique
component installed.

10. Manufacturer recommended spares: Supply spare parts equal to at least one set.

C. All spare parts shall be packaged to prevent damage during long-term storage. Identified all packages with indelible markings on the exterior describing contents.

D. Provided complete ordering information including manufacturer, part number, part name, hardware and software revision levels, and equipment for which the part is to be used.

1.6 SPARE I/O

A. Each I/O drop and I/O location shall include at least 20 percent (minimum of four) points of each type (AI, AO, DI, and DO) for future use, regardless of whether any of those point types are used in that drop or location or not. The spares shall be the same type of I/O modules supplied.

B. Spare output points that require the use of an external relay shall be supplied with the external relay.

C. Regardless of the spare requirement, all installed unused points on all I/O modules shall be wired to terminal blocks in the order that they occur on the I/O modules. Unwired spares shall not be acceptable.

PART 2 PRODUCTS

2.1 GENERAL

A. Provide Programmable Logic Controller equipment with the required memory and functional capacity to perform the specified sequence of operation with the scheduled input and output points.

B. Processor Systems shall include processor, power supply, input/output modules, communication modules, redundancy modules, and remote interface modules as required to meet system requirements.

C. Furnish products listed and classified by Underwriters Laboratories (UL), CSA, or FM approval as suitable for purpose specified and indicated.

D. All equipment and devices furnished hereunder shall be designed for continuous industrial service. The system shall contain products of a single manufacturer, insofar as possible, and shall consist of equipment models that are currently in production.

E. All equipment furnished shall be designed and constructed so that in the event of power interruption the systems shall go through an orderly shutdown with no loss of memory, and resume normal operation without manually resetting when power is restored.

F. The PLCs shall communicate between the operator workstation and field-mounted transducers, switches, controllers, and process actuators. Communications protocol shall be completely transparent to process operators at the Human Machine Interface (HMI).
G. The PLC shall be capable of stand-alone operation in the event of failure of the communication link to the HMI subsystem.

H. Agency and environmental specifications:

1. Electrical supply voltage to the PLC shall be 120 Vac, plus or minus "15 percent, 48-63Hz. PLC system power supplies shall be fused for overload protection.

2. Vibration: 3.5 mm Peak-to-Peak, 5-9 Hz: 1.0G, 9-150Hz. The method of testing is to be based upon IEC 68-2-6 and JIS C 0911 standards for vibration. The system is to be operational during and after testing. Vibration Rating of 2.0G maximum peak acceleration for 10 to 500Hz. in accordance with at least one of the following:
   a. Installed rating: DIN rail mounted PLC: 10-57 Hz, amplitude 0.075 mm, acceleration 25-100 Hz, and
   b. Panel or plate mounted PLC: 2-25 Hz, amplitude 1.6mm, acceleration 25-200 Hz.
   c. In compliance with IEC 60068 and IEC 61131.

3. Shock: 15G, 11 msec. The method of testing is to be based upon IEC 68-2-27 and JIS C 0912 standards for shock. The system is to be operational during and after testing.

4. Temperature: All PLC hardware shall operate at an ambient temperature of 0 to +55 degrees C (+32 to +140 degrees F), with an storage ambient temperature rating of -25 to +70 degrees C (-40 to +185 degrees F).

5. Relative Humidity: The Programmable Controller hardware shall function continuously in the relative humidity range of 30 percent to 95 percent non-condensing.


7. Altitude:
   a. Operation: 0-6,500 feet
   b. Storage: 0-9,800 feet

8. Degree of protection: NEMA 1 (IP20)

9. All products shall have corrosion protection.

I. All major assemblies and sub-assemblies, circuit boards, and devices shall be identified using permanent labels or markings indicating:

1. Modules product type such as analog or digital
2. Modules catalog number
3. Modules major revision number
4. Modules minor revision number
5. Module manufacturer vendor
6. Module serial number

J. All necessary cables shall be included. All cables and connectors shall be as specified by the manufacturer. Cables shall be assembled and installed per the manufacturer recommendations.

K. MANUFACTURERS

1. Provide all PLCs from a single manufacturer. If the PLC manufacturer has authorized third party vendors to provide modules that are compatible with their platforms, then products manufactured by these authorized third party vendors will be acceptable.

2. Provide the following PLC system:
   a. **Rockwell Automation Allen Bradley ControlLogix**

L. Central Processing Unit (CPU)

1. The CPU shall be, at a minimum, Rockwell Automation 1756-L72

M. Memory

1. The user program and data shall be contained in non-volatile memory.
2. Memory Backup: Capacitor energy storage module.

N. Communication Ports

1. The CPU shall be expandable and supplied with additional modules to support the required communication interfaces.

2.2 POWER SUPPLIES

A. The PLC shall have chassis mounted power supplies to power the chassis backplane, and provide power for the processor and applicable modules.

2.3 CHASSIS

A. PLC models shall be chassis based and shall contain 17 slots.

2.4 DISCRETE INPUT AND OUTPUT MODULES

A. General
1. Digital input and output modules shall provide ON/OFF detection and actuation.

2. The I/O count and type shall be as required to implement the functions specified plus an allowance for active spares, as noted below.

3. Modules shall be designed to be installed or removed while chassis power is applied.

4. Modules shall have indicators to display the status of communication, module health and input / output devices.

5. Each module shall have the following status indicators.
   a. The On/Off state of the field device.
   b. The module’s communication status.

6. I/O modules shall contain a maximum of 16 points per module.

B. Module Specifications (120Vac Isolated Input Module)

1. Nominal Input Voltage of 120V ac

2. On-State Current of 15mA @132V ac, 47-63Hz maximum

3. Maximum Off-State Voltage of 20V

4. Maximum Off-State Current of 2.5mA

C. Module Specification (120Vac Isolated Output Module)

1. Each triac type discrete output shall have an associated interposing relay located in the same control panel. 120 VAC power for relay outputs shall be provided from the associated motor starter control circuit (when used with motor starters) or other 120 VAC source (when I/O is not associated with a particular motor starter).

2. Output Voltage Range of 74-265V ac, 47-63Hz

3. Output Current Rating:
   a. Per Point - 2A maximum @ 30 degrees C; 1.0A maximum @ 60 degrees C; Linear Derating
   b. Per Module - 5A maximum @ 30 degrees C; 4A maximum @ 60 degrees C; Linear Derating

4. Surge Current Per Point of 20A for 43ms each, repeatable every 2s @ 60 degrees C

5. Minimum Load Current of 10mA per point

6. Maximum On-State Voltage Drop of 1.5V peak @2.0A and 6V peak @load less than 50mA
7. Maximum Off-State Leakage of 3mA per point

D. Module Specifications (Contact Output Module)

1. Output Voltage Range of 10-265V ac, 47-63Hz

2. Output Current Rating:
   a. Resistive - 2A @ 125V ac
   b. Inductive - 2A Steady State, 15A make @125V ac

3. Power Rating (Steady State) of 250VA maximum for 125V ac inductive output

4. Maximum Off-State Leakage of 0 mA per point

5. Configurable States
   a. Fault Per Point - Hold Last State, ON or OFF
   b. Program Mode Per Point - Hold Last State, ON or OFF

2.5 ANALOG INPUT AND OUTPUT MODULES

A. General

1. Analog input modules shall convert an analog signal that is connected to the module’s screw terminals into a digital value. The digital value representing the magnitude of the analog signal shall be transmitted on the backplane. Analog output modules shall convert a digital value that is delivered to the module via the backplane into an analog signal on the module’s screw terminals.

2. Modules shall be designed to be installed or removed while chassis power is applied.

3. Modules shall have indicators to display the status of communication, module health and input / output devices.

4. Each analog module shall provide both hardware and software indication when a module fault has occurred. Each module shall have an LED fault indicator and the programming software shall display the fault information.

5. Analog modules shall be software configurable through the I/O configuration portion of the programming software.

6. The following status shall be capable of being examined in ladder logic
   b. Channel Fault Word – Provides under-range, over-range and communications fault reporting.
   c. Channel Status Words – Provides individual channel under-range and over-range
fault reporting for process alarm, rate alarms and calibration faults.

7. The 24 VDC power for analog instrument loops shall be provided as a part of the system. The 24 VDC power supply shall be derived from the 120 VAC input power circuit to the PLC. The field side of the 24 VDC power sources(s) shall have individual or grouped (of logically associated circuits) fusing and be provided with a readily visible, labeled blown fuse indicator.

B. Isolated Analog Input Module

1. Input Range of 0-20 mA
2. Resolution of approximately 16 bits across range
3. Input Impedance of Greater than 249 Ohms
4. Overvoltage Protection: 8V ac/dc with on-board current resistor
5. Normal Mode Rejection of 60dB at 60Hz
6. Common Mode Noise Rejection of 120dB at 60Hz, 100dB at 50Hz
7. Isolation Voltage
   a. Channel to Channel - 100% tested at 1700V dc for 1s based on 250V ac
   b. User to System - 100% tested at 1700V dc for 1s based on 250V ac

C. Isolated Analog Output Current Module

1. Output Current Range of 4 to 20 mA
2. Current Resolution of 12 bits across 20 mA
3. Open Circuit Detection – None
4. Output Overvoltage Protection - 24V ac/dc maximum
5. Output Short Circuit Protection – 20 mA or less (electronically limited)
6. Calibration Accuracy - Better than 0.1% of range from 4mA to 20 mA
7. Calibration Interval - 12 months typical

2.6 COMMUNICATION INTERFACES

A. The PLC will be capable of the following communication protocols as shown on the drawings:

1. 10BASE-T/100BASE-TX Ethernet communication.
2. Modbus (RTU and ASCII) for up to 247 slaves
B. When required provide an Communications Interface Module mounted in the chassis or the equivalent port directly on the CPU.

2.7 RTD MODULES
A. RTD input modules shall be provided and coordinated with the RTD’s being supplied with the pumps and motors.

2.8 PLC SOFTWARE
A. The integrator shall provide a PLC configuration and application development software package (RSLogix 5000) complete with documentation and media.
B. RS Logix 5000 Software and Media with Rockwell activation codes shall be delivered to Water Pollution Control Support Services staff for installation on secure City owned PLC programming laptops assigned to Northside staff.

PART 3 EXECUTION
3.1 GENERAL INSTALLATION
A. Maintain area free of dirt and dust during and after installation of programmable controller products.
B. Anchor PLCs within enclosures as recommended by the PLC manufacturer.
C. Ventilation slots shall not be blocked, or obstructed by any means.
D. Examine areas, surfaces, and substrates to receive PLCs for compliance with requirements, installation tolerances, and other conditions affecting performance. Proceed with installation only after unsatisfactory conditions have been corrected.
E. Install in accordance with manufacturer’s instructions.
F. Unload, unpack and transport equipment to prevent damage or loss.
G. Replace damaged components as directed by Engineer.

3.2 PANEL LAYOUT
A. Coordinate size and configuration of enclosure to meet project requirements. Drawings indicate maximum dimensions for PLCs, minimum clearances between PLCs, and adjacent surfaces and other items.
B. Comply with indicated maximum dimensions and clearances, or with PLC vendors required distances if they are greater then the distances indicated.
C. Provide spacing around PLC as required by the PLC manufacturer to insure adequate
cooling. Insure that the air surrounding the PLC has been conditioned to maintain the required temperature and humidity range.

1. Wires entering and exiting PLC components shall be sized to comply with the PLC manufacturers requirements. Doors on all components shall be able to be fully closed when all the wires are installed.

2. For chassis mounted PLCs, no wiring, wire ducts, or other devices shall obstruct the removal of cards from the rack.

3. PLC lights, keys, communication ports, and memory card slots shall be accessible at all times. Lights shall be visible at all times when enclosure door is opened.

D. Control panel designer shall provide independent line fuses or circuit breakers, per the PLC manufacturer recommendation, for each power supply, input module, output module, and other modules with separately derived power requirements.

E. Control panel designer shall insure that communication signals, 4-20mA signals (including those with embedded HART), are properly conditioned for the PLC and protected from all sources of radiated energy or harmonics.

F. Each PLC (including all I/O) shall be powered from the UPS power conditioning system.

G. Provide all required cables, cords, and connective devices for interface with other control system components.

H. PLC vendors shall supply PLC programming and electronic documents on DVD or CD with complete program listing and comprehensive documentation to WPC ICS Administration.

I. Contracts and service vendor shall document all PLC programming logic and special functions within the programming code in detail sufficient to allow Third Party repair or functional replacement and provide a Functional Flow Block Diagram (FFBD) of any automation programming.

J. Contractors and employees working directly on equipment or installing control software must possess an ODEQ Class B certification or be supervised by someone who does.

K. Reference ODEQ Certification Rules "252:710-3-31 Certificate required" and "252:710-3-34 Classes of certifications"

L. All documentation shall be provided in both paper and electronic form

1. Electronic documentation

2. DVD

3. Microsoft Office application format or Adobe Acrobat PDF format only

END OF SECTION
PART 1  GENERAL

1.1  SCOPE OF WORK

A. This Section describes the requirements for the Human Machine Interface (HMI) software and the Application Engineering Services.

PART 2  PRODUCTS

2.1  SPECIFIC GRAPHIC DISPLAYS

A. Process graphic displays, shall be based on the P&ID’s, site plan drawings, mechanical drawings and electrical drawings included in these contract documents. The graphic displays shall depict process flow streams, process structures, and all major items of process equipment and control devices in a schematic format.

B. Animation shall be provided to mimic level changes in tanks or vessels, and to mimic rotation of rotating equipment when running. Valve colors shall change when opened and closed.

C. Color coding for equipment status and alarms shall what is currently in use.

D. At a minimum, provide the number of screen displays required below. In addition, provide pop-up screens as appropriate to allow control of individual equipment items.

E. All main graphical screens shall include a title bar, main graphic area, navigational buttons, and alarm summary bar. Title bar shall be displayed on the top of each screen and include display name, description and time/date. The main graphical area shall contain primary screen data in graphical format. Navigational buttons shall include a minimum of main menu, trends, main alarm summary, and security log in. The alarm summary bar shall display the last three valid alarms on the bottom of each screen. The following types of displays shall be included as a minimum:

1. Pump station overview screen shall include a site plan representation, indicating the geographic location of each process, and each building.

2. Main menu screen shall be developed to connect to all screens and process areas.

3. Overall process block flow diagram screen shall show all major processes in block form with flow arrows. Each block shall include a text description of key individual treatment processes. Navigational buttons to the individual treatment processes shall be performed by pressing on the text description.

4. Individual treatment process screens shall graphically display key process variables and equipment. No operator entries shall be done from these screens. Individual process flow screens for each process shall include all process components, including tanks, pumps, blowers, mixers, drives, flow meters, valves, mechanical devices, as well as manual shutoff and isolation valves. These diagrams shall be generally depicted from the P&ID’s and there shall be at least 1 screen per P&ID on average.
5. Individual unit process screens depicted from the P&ID’s are used for control and display of each major item of process equipment, process variables, and control devices, including pumps, blowers, valves, gates, mixers, drives etc. Navigational buttons shall consist of the P&ID’s flow arrows to other individual unit processes. The unit process screens shall provide the ability for the operator to go to individual equipment popup screens. These diagrams shall be generally depicted from the P&ID’s and there shall be at least 2 screens per P&ID on average.

6. Popup screens shall be provided for each piece of equipment to start/stop equipment, open / close valves, implement automatic control, adjust set points, establish and adjust tuning parameters, set alarm limits and initiate a sequence.

7. PLC system diagnostic displays, showing the operational status, and fault conditions of all PLC components, including processors, I/O modules, OIT’s, power supplies and UPS units.

8. Communications diagnostic displays, showing the operational status and fault conditions of all major components including Operator Work Stations, peripheral devices and network components.

9. Maintenance screens to display the raw status of every I/O point on an I/O card basis and will allow the operators/maintenance personnel to enter a value for an analog point that will used by the system instead of the value read from the input card / communications link.

10. Trend screens with the capability to display up to eight, operator assigned, analog and or digital process variables. Each analog value will be shown on a trend screen.

11. The main alarm summary screen shall display the following information on each alarm: Time, tag name, description, alarm type, current value and status. An acknowledge alarm button shall acknowledge all new unacknowledged alarms. The acknowledged and unacknowledged alarms shall be different colors. Acknowledged alarms shall clear automatically after the condition is corrected.

12. Analog variable screens showing a tabular summary of all plant process variables, in operator assigned groupings.

2.2 ALARM/EQUIPMENT STATUS REPORTING

A. The alarm log shall display all alarms as they occur. The alarm message shall include the time of occurrence, tag name, tag number, and whether it is a low, high, or failure alarm. When the point in alarm returns to normal, the time, point identification number, and return to normal shall be displayed. All reports shall include the plant equipment number of the associated device.

B. The equipment status shall be logged whenever a change in status occurs (i.e., start, stop). The equipment status log shall include the time, equipment name, tag number, and the particular change in status.

PART 3 EXECUTION

END OF SECTION
PART 1 GENERAL

1.1 SCOPE OF WORK

A. Furnish all labor and materials required and installed. Complete as shown on the Drawings and as specified herein.

B. The System Integrator shall furnish the labor and materials required to install and bring into operation the control and data network as shown on the Drawings and specified herein.

C. The network shall be capable of supporting communications between all servers, operator workstations, PLCs, RTUs, and other communication devices as shown on the system architecture block diagram(s). The System Integrator shall furnish all necessary cables, face plates, connectors, modems, transceivers, repeaters, modules; splice kits, etc. required for a complete and operational network. The system architecture diagram(s) are for network understanding only. Some communication devices maybe required for network operation, which may not be explicitly shown on the Drawings. The system shall be designed to accommodate an increase of 100 percent of network nodes.

PART 2 PRODUCTS

1.2 GENERAL

A. The use of a manufacturer's name and model or catalog number is for the purpose of establishing the standard of quality and general configuration desired.

B. ALL SUBMITTALS for ethernet hardware and communication media including fiber optic cable and the installation thereof and media converters and switches should be submitted to Mr. Ken Neal, CoT Network Services Manager kneal@cityoftulsa.org for review and approval for compliance with COT Secure Network standards and requirements.

1.3 UNMANAGED ETHERNET SWITCHES

A. General

1. Provide unmanaged Ethernet switch(s) for connection to the control network backbone as shown in the Drawings and specified herein.

B. Physical Features

1. Copper ports: 4 – 10/100 TX RJ45 ports, minimum

2. Operating temperature: 32 to 130 degrees f
3. Power: 24 VDC
4. Enclosure: Metal case, DIN-rail mountable
5. Rating: UL Class 1, Division 2 Groups A, B, C, and D

C. Network Features
   1. Auto sensing duplex and speed
   2. LED link/activity status indication

D. Acceptable Manufacturers
   1. Phoenix contact
   2. N-Tron
   3. Moxa
   4. Or equal

1.4 ETHERNET MEDIA CONVERTERS

A. General
   1. Provide Ethernet media converter(s) as shown in the Drawings and specified herein.

B. Physical Features
   1. RJ45 ports: 10/100BaseTX to 100BaseTX
   2. Fiber uplinks: 100BaseTX to 100BaseFX (ST/SC connectors)
   3. Fiber optics: Multi- or single-mode capability as shown in the Drawings
   4. Operating temperature: 32 to 130 degrees f
   5. Power: 24 VDC
   6. Enclosure: DIN-rail mountable

C. Acceptable Manufacturers
   1. Phoenix Contact
   2. N-Tron
   3. Moxa
4. Or Equal

1.5 WIRES AND CONNECTORS

A. Ethernet 10/100/1000 BASE-T/TX Cable.

1. The unshielded twisted pair cable shall be designed for use with a high speed (10/100/1000 Mbps) Ethernet 10/100/1000 BASE-T/TX communications network. The twisted pair cable shall have a nominal impedance 100 ohms at one MHz, a maximum attenuation of 8 dB per 1000 feet at one MHz. The twisted pair cable must have frequency tested up to 250 MHz or more. The twisted pair cable shall be plenum rated and shall have a minimum of four 23 AWG solid copper conductor pairs. All 10/100/1000 BASE-T/TX (RJ-45) terminations on the twisted pair cable shall be done in a professional and workman like manner. Terminations shall provide for proper strain relief on the cable jacket. Strain relief on the wire and/or wire insulation shall not be acceptable.

PART 3 EXECUTION

END OF SECTION
PART 1  GENERAL

1.01  SCOPE OF WORK

A. Furnish and install control panels and equipment as specified herein and shown on the Drawings.

PART 2  PRODUCTS

2.01  CONTROL PANEL GENERAL REQUIREMENTS

A. The dimensions within this Section and on the Contract Drawings are for general reference only. Ensure that final enclosure sizing and panel arrangements accommodate all required equipment for a fully integrated and operational system as specified herein and in the Contract Documents.

B. All panel doors shall have a lock installed in the door handle, or a hasp and staple for padlocking. Locks for all panels provided under this Contract shall be keyed alike.

C. The devices designated for rear-of-panel mounting shall be arranged within the panel according to respective panel drawings and in a manner to allow for ease of maintenance and adjustment. Heat generating devices such as power supplies shall be located at or near the top of the panel.

D. The panels shall be completely fabricated, instruments and devices installed and wired at the System integrators facility.

E. All components shall be mounted in a manner that shall permit servicing, adjustment, testing, and removal without disconnecting, moving, or removing any other component. Components mounted on the inside of panels shall be mounted on removable plates and not directly to the enclosure. Mounting shall be rigid and stable unless shock mounting is required otherwise by the manufacturer to protect equipment from vibration. Component mounting shall be oriented in accordance with manufacturer’s recommendations. The internal components shall be identified with suitable plastic or metal engraved nametags mounted adjacent to (not on) each component identifying the component in accordance with the drawing, specifications, and System Integrator’s data.

F. All exterior panel mounted equipment shall be installed with suitable gaskets, faceplates, etc. required to maintain the NEMA rating of the panel.

G. Nameplates

1. All panels and panel devices shall be supplied with suitable nameplates, which identify the panel and individual devices as required. Unless otherwise indicated, each device nameplate shall include up to three lines with the first line containing the device tag number as shown on the drawings, the second line containing a functional description (e.g., Recirculation Pump No. 1), and the third line containing a functional control description (e.g., Start).

2. Unless escutcheon plates are specified or unless otherwise noted on the Drawings, nameplates shall be 3/32-inch thick, black and white, Lamicoid with engraved inscriptions. The letters shall be Black against a White background unless
otherwise noted. Edges of the nameplates shall be beveled and smooth. Nameplates with chipped or rough edges will not be acceptable.

3. Nameplate fasteners and mounting shall be epoxy adhesive or stainless steel screws for cabinet mounted nameplates

4. For every panel, provide a panel nameplate with a minimum of 1" high letters. Provide legend plates or 1-in by 3-in engraved nameplates with 1/4-in lettering for identification of door mounted control devices, pilot lights, and meters.

5. Single lamicoid nameplates with multiple legends shall be used for grouping of devices such as selector switches and pilot lights that relate to one function.

H. Mounting Elevations

1. ISA Recommended Practice RP60.3 shall be used as a guide in layout and arrangement of panels and panel mounted components. Dimensions shall account for all housekeeping pads that panels will sit on once they are installed.

2. Centerline of indicators and controllers shall be located no lower than 48-inches or higher than 66-inches above the floor on a panel face.

3. Centerline of lights, selector switches, and pushbuttons shall be located no lower than 32-inches or higher than 70-inches above the floor on a panel face.

4. Tops of annunciators shall be located no higher than 86-inches above the floor on a panel face.

5. Installation of panel components shall conform to component manufacturers' guidelines.

2.02 PANEL MATERIALS AND CONSTRUCTION

A. Structure and Enclosure

1. Panels shall be of continuous welded-steel or FRP construction as shown on the Panel Schedule. Provide angle stiffeners as required on the back of the panel face to prevent panel deflection under instrument loading or operation. Internally the panels shall be supplied with a structural framework for instrument support purposes and panel bracing. The internal framework shall permit panel lifting without racking or distortion. Provide removable lifting rings designed to facilitate simple, safe rigging, and lifting of the control panels during installation.

2. Each panel shall be provided with full height, fully gasketed access doors where shown. Doors shall be provided with a three-point stainless steel latch (except for NEMA 4X panels) and heavy duty stainless steel locking handle. Rear access doors (if included) shall be conveniently arranged and sized such that they extend no further than 24-inches beyond the panel when opened to the 90-degree position. Front and side access doors shall be as shown. Panel access doors shall be provided with full length, continuous, piano type stainless steel hinges with stainless steel pins. Front access doors with mounted instruments or control devices shall be of sufficient width to permit door opening without interference from flush mounted instruments.
3. The panels, including component parts, shall be free from sharp edges and welding flaws. Wiring shall be free from kinks and sharp bends and shall be routed for easy access to other components for maintenance and inspection purposes.

4. The panel shall be suitable for top and bottom conduit entry as required by the Electrical Drawings. For top mounted conduit entry, the panel top shall be provided with nominal one-foot square removable access plates, which may be drilled to accommodate conduit and cable penetrations. All conduit and cable penetrations shall be provided with ground bushings, hubs, gasketed locknuts, and other accessories as required to maintain the NEMA rating of the panel and electrical rating of the conduit system.

5. All panels in indoor, dry, non-corrosive environments shall be NEMA 12 unless otherwise noted. All panels in outdoor, wet, and non-chemically corrosive environments shall be NEMA 4 unless otherwise noted. Panels in chemically corrosive environments shall be NEMA 4X unless otherwise noted. All panels located in a hazardous location shall be rated for the type of hazard (e.g., NEMA 7 for Class 1, Division 1).

B. Freestanding and Floor-Mounted Vertical Panels

1. Freestanding and floor-mounted vertical panels shall meet the NEMA classification as shown on the drawings or specified herein. The panels shall be constructed of 12 gauge sheet steel, suitably braced internally for structural rigidity and strength. All NEMA 4X rated panels shall be constructed of 316 stainless steel, unless FRP is specifically indicated to be provided. Front panels or panels containing instruments shall be not less than 10 gauge stretcher leveled sheet steel, reinforced to prevent warping or distortion.

C. Wall and Unistrut Mounted Panels

1. All wall and Unistrut mounted panels shall meet the NEMA classification as shown on the drawings or specified herein. The panels shall be constructed of not less than USS 14 gauge steel, suitably braced internally for structural rigidity and strength. All NEMA 4X rated wall mounted panels shall be constructed of 316 stainless steel, unless FRP is specifically indicated. FRP panels shall be used in chlorine areas. All FRP panels located in direct sunlight shall be provided with a protective coating and sun shield to prevent discoloration and cracking.

D. Finish Requirements

1. All sections shall be descaled, degreased, filled, ground and finished. The enclosure when fabricated of steel shall be finished with two rust resistant phosphate prime coats and two coats of enamel, polyurethane, or lacquer finish which shall be applied by either the hot air spray or conventional cold spray methods. Brushed anodized aluminum, stainless steel, and FRP panels will not require a paint finish.

2. The panels shall have edges ground smooth and shall be sandblasted and then cleaned with a solvent. Surface voids shall be filled and ground smooth.

3. Immediately after cleaning, one coat of a rust-inhibiting primer shall be applied inside and outside, followed by an exterior intermediate and top coat of a
two-component type epoxy enamel. A final sanding shall be applied to the intermediate exterior coat before top coating.

4. Apply a minimum of two coats of flat white lacquer on the panel interior after priming.

5. Unless otherwise noted, the finish exterior colors shall be ANSI 61 gray with a textured finish.

E. Print storage pockets shall be provided on the inside of each panel. The storage pockets shall be steel, welded on to the door, and finished to match the interior panel color. The storage pocket shall be sufficient to hold all of the prints required to service the equipment, and to accommodate 8.5 inch by 11 inch documents without folding.

2.03 ENVIRONMENTAL CONTROL

A. All panels shall be provided with louvers, sun shields, heat sinks, forced air ventilation, or air conditioning units as required to prevent temperature buildup inside of panel. The internal temperature of all panels shall be regulated to a range of 45 Deg F to 104 Deg F under all conditions. Under no circumstances shall the panel cooling or heating equipment compromise the NEMA rating of the panel.

B. Except for panels mounted with their backs directly adjacent to a wall, louvers shall be in the rear of the panels, top and bottom, and shall be stamped sheet metal construction.

C. For panels mounted with their backs directly adjacent to a wall, louvers shall be on the sides.

D. Forced air ventilation fans, where used, shall provide a positive internal pressure within the panel, and shall be provided with washable or replaceable filters. Fan motors shall operate on 120-volt, 60-Hz power.

E. For panels with internal heat that cannot be adequately dissipated with natural convection and heat sinks, or forced air ventilation, an air conditioner shall be provided.

2.04 CORROSION CONTROL

A. Panels shall be protected from internal corrosion by the use of corrosion-inhibiting vapor capsules as manufactured by Northern Technologies International Corporation, Model Zerust VC; Hoffman Model AHCI; or equal.

2.05 CONTROL PANEL - INTERNAL CONSTRUCTION

A. Internal Electrical Wiring

1. All interconnecting wiring shall be stranded, type MTW, and shall have 600 volt insulation and be rated for not less than 90 degrees Celsius. Wiring for systems operating at voltages in excess of 120 VAC shall be segregated from other panel wiring either in a separate section of a multi-section panel or behind a removable Plexiglas or similar dielectric barrier. Panel layout shall be developed such that technicians shall have complete access to 120 VAC and lower voltage wiring systems without direct exposure to higher voltages.

2. Power distribution wiring on the line side of fuses or breakers shall be 12 AWG
minimum. Control wiring on the secondary side of fuses shall be 16 AWG minimum. Electronic analog circuits shall utilize 18 AWG shielded, twisted pair, cable insulated for not less than 600 volts.

3. Power and low voltage DC wiring systems shall be routed in separate wireways. Crossing of different system wires shall be at right angles. Different system wires routed parallel to each other shall be separated by at least 6-inches. Different wiring systems shall terminate on separate terminal blocks. Wiring troughs shall not be filled to more than 60 percent visible fill.

4. Terminations

a. All wiring shall terminate onto single tier terminal blocks, where each terminal is uniquely and sequentially numbered. Direct wiring between field equipment and panel components is not acceptable.

b. Multi-level terminal blocks or strips are not acceptable.

c. Terminal blocks shall be arranged in vertical rows and separated into groups (power, AC control, DC signal). Each group of terminal blocks shall have a minimum of 25 percent spares.

d. Terminal blocks shall be the compression type, fused, unfused, or switched as shown on the Contract Drawings or specified elsewhere in Division 13.

e. Discrete inputs and outputs (DI and DO) shall have two terminals per point with adjacent terminal assignments. All active and spare PLC and controller points shall be wired to terminal blocks.

f. Analog inputs and outputs (AI and AO) shall have three terminals per shielded pair connection with adjacent terminal assignments for each point. The third terminal is for shielded ground connection for cable pairs. Ground the shielded signal cable at the PLC cabinet. All active and spare PLC and controller points shall be wired to terminal blocks.

g. Wire and tube markers shall be the sleeve type with heat impressed letters and numbers.

h. Only one side of a terminal block row shall be used for internal wiring. The field wiring side of the terminal shall not be within 6-inches of the side panel or adjacent terminal or within 8-inches of the bottom of free standing panels, or within 3-inches of stanchion mounted panels, or 3-inches of adjacent wireway.

i. Circuit power from the SCADA cabinet out to field devices (switches, dry contacts etc.) that are used as discrete inputs to the PLC input cards shall be isolated with an isolating switch terminal block with flip cover that is supplied with a dummy fuse. Isolation switch block shall be an Allen Bradley Model 1492-H7 or equal. One isolating switch terminal block per loop numbered piece of equipment and one per spare I/O point is acceptable.

j. All PLC discrete outputs to the field shall be isolated with an isolating fuse switch terminal block with a flip cover and a neon blown fuse indicator. The
CONTROL PANELS AND EQUIPMENT
13.5 - 6

single circuit fusible terminal block shall be an Allen Bradley 1492-H4 or equal.

5. All wiring to hand switches and other devices, which are live circuits independent of the panel’s normal circuit breaker protection, shall be clearly identified as such.

6. All wiring shall be clearly tagged and color coded. All tag numbers and color coding shall correspond to the panel wiring diagrams and loop drawings prepared by the System Integrator. All power wiring, control wiring, grounding, and DC wiring shall utilize different color insulation for each wiring system used. The color coding scheme shall be:

   a. Incoming 120 VAC Hot - Black
   b. 120 VAC Hot wiring downstream of panel circuit breaker – Red
   c. 120 VAC Hot wiring derived from a UPS system – Red with Black stripe
   d. Three phase power – Brown, Orange, Yellow, and Green ground or as specified in Division 16.
   e. 120 VAC neutral - White
   f. Ground - Green
   g. DC power or control wiring – Blue
   h. DC analog signal wiring – Black (+), White (-)
   i. Foreign voltage – Yellow

7. Provide surge protectors on all incoming power supply lines at each panel per the requirements of Section 13300.

8. Provide redundant 24 VDC power supplies to power field instruments and panel devices. Twenty-four VDC power supplies shall be as specified in this Section.

9. Wiring trough for supporting internal wiring shall be plastic type with snap-on covers. The side walls shall be open top type to permit wire changing without disconnecting. Trough shall be supported to the subpanel by stainless steel screws. Trough shall not be bonded to the panel with glue or adhesives.

10. Each panel shall have a single tube, fluorescent light fixture, 20 Watt in size, mounted internally to the ceiling of the panel. Light fixture shall be switched and shall be complete with the lamp.

11. Each panel shall have a specification grade duplex convenience receptacle with ground fault interrupter, mounted internally within a stamped steel device box with appropriate cover. Convenience receptacle shall not be powered from a UPS and shall be protected by a dedicated fuse or circuit breaker.

12. Each panel shall be provided with an isolated copper grounding bus for all signal and shield ground connections. Shield grounding shall be in accordance with the instrumentation manufacturer's recommendations.
13. Each panel shall be provided with a separate copper power grounding bus (safety) in accordance with the requirements of the National Electrical Code.

14. Each panel shall have control, signal, and communication line surge suppression in accordance with Section 13300.

15. All microprocessor-based electronic devices in the panel that are powered by 120VAC shall be powered by the UPS.

16. Each panel shall be provided with a circuit breaker to interrupt incoming power. Provide a minimum of two (2) spare 20-amp breakers.

17. Additional electrical components including transformers, motor starters, switches, circuit breakers, etc. shall be in compliance with the requirements of Division 16.

B. Relays not provided under Division 16 and required for properly completing the control function specified in Division 13, Division 16, or shown on the Drawings shall be provided under this Section.

C. The orientation of all devices including PLC and I/O when installed shall be per the manufacturer’s recommendations. No vertical orientation of PLC racks shall be allowed unless specifically indicated by the manufacturer as an acceptable mounting alternative and also approved by the engineer.

2.06 ELECTRICAL COMPONENTS

A. The main circuit breaker shall be a thermal-magnetic molded case breaker, by Square D Company, or equal. Provide a flange mounted main power disconnect operating handle with mechanical interlock having a bypass that will allow the panel door to open only when the switch is in the OFF position.

B. A mechanical disconnect mechanism, with bypass, shall be installed on each motor circuit protector, capable of being locked in the "OFF" position to provide a means of disconnecting power to the motor.

C. Auxiliary contacts shall be provided for remote run indication and indication of each status and alarm condition. Additional controls shall be provided as specified herein and as required by the detailed mechanical equipment requirements, the P&IDs (Division 13), the Control Wiring Diagrams (Division 16) and as shown on the Drawings.

D. All operating control devices and instruments shall be securely mounted on the exterior door. All controls shall be clearly labeled to indicate function and shall be in accordance with the electrical area classification indicated on the Electrical Contract Drawings.

E. A six digit, non-resettable quartz time base elapsed time meter shall be connected to each motor starter. Meter shall be Hobbs 98000 Series, Redington Model 722, Cramer Model ETI-635 G, or equal.

F. The control panel shall be provided with a lightning and surge protection unit on the line side of the main circuit breaker. Unit shall be 600 Volt, 3 Phase, General Electric "Tranquell" Series, or equal.

G. Where required by Specifications, an alternator shall be provided to sequence motors.
Alternator shall be Catalog No. 008-120-13SP or 009-120-23AP by Stacon; Square D, Class 9039, Type HG-21 or equal.

H. Panel mounted timers shall be flush mounted, plug-in type, Eagle Signal Bulletin 125 cycle-flex, Idec SR6P-MO8G or equal, with ranges as shown on the Drawings, or as required by the detailed mechanical equipment specifications.

I. Specific control devices, control descriptions and other data are specified under the detailed specification for the mechanical equipment with which the control panel is supplied.

2.07 GENERAL PURPOSE RELAYS AND TIME DELAYS

A. Type:

1. General purpose plug-in type.

B. Functional:

1. Contact arrangement/function shall be as required to meet the specified control function; Mechanical life expectancy shall be in excess of 10 million.

2. Duty cycle shall be rated for continuous operation; Units shall be provided with integral indicating light to indicate if relay is energized.

3. Solid state time delays shall be provided with polarity protection (DC units) and transient protection.

4. Time delay units shall be adjustable and available in ranges from .1 second to 4.5 hours.

C. Physical:

1. For 120 VAC service provide contacts rated 10 amps at 120 VAC, for 24 VDC service provide contacts rated 5 amps at 28 VDC, for electronic (milliamp/millivolt) switching applicator provide gold plated contacts rated for electronic service; relays shall be provided with dust and moisture resistant covers.

D. Options/Accessories Required:

1. Provide mounting sockets with pressure type terminal blocks rated 300 volt and 10 amps.

2. Provide mounting rails/holders as required.

E. Manufacturer(s):

1. IDEC.


4. Equal.
2.08 INTRINSICALLY SAFE RELAYS

A. Type:

1. Relays shall be of the solid state electronic type in which the energy level of the sensing or actuation circuit is low enough to allow safe usage in hazardous areas.

B. Options Required:

1. Relays shall match power supply provided.
2. Relays shall be located in non-hazardous areas.

C. Manufacturer(s):

1. Consolidated Electric.
2. Gems Safe-Pak.
3. Warrick Controls.
4. R. Stahl, Inc.
5. Equal.

2.09 INTRINSIC SAFETY BARRIERS (FOR 2-WIRE TRANSMITTER SYSTEMS)

A. Intrinsic safety barriers shall be passive devices requiring no external voltage supply and supplied with series resistors, series fuse and shunt zener diodes to limit the transfer of energy to levels required by intrinsically safe protection between safe and hazardous locations.

B. Unit shall be Factory Mutual approved and certified for use in accordance with National Fire Protection Association (NFPA 493).

C. Manufacturer(s):

1. P&F.
2. Gems.
3. Unitech.
4. Equal.

2.10 24 VDC POWER SUPPLIES

A. Provide a 24 VDC power supply in the control panel to power field instruments, panel devices, etc., as required. Equip the power supply with a power on/off circuit breaker.

B. The 24 VDC power supply shall meet the following requirements:

1. Input power: 115 VAC, plus or minus 10 percent, 60 Hz.
2. Output voltage: 24 VDC.

3. Output voltage adjustment: 5 percent.

4. Line regulation: 0.05 percent for 10 volt line change.

5. Load regulation: 0.15 percent no load to full load.

6. Ripple: 3 mV RMS.

7. Operating temperature: 32 to 140 degrees Fahrenheit.

C. Size the 24 VDC power supply to accommodate the design load plus a minimum 25 percent spare capacity.

D. If power supply on/off status signal is shown, provide a relay contact (internal to the power supply or external if the power supply is not so equipped) to indicate on/off status of the power supply.

E. Provide output overvoltage and overcurrent protective devices with the power supply to protect instruments from damage due to power supply failure and to protect the power supply from damage due to external failure.

F. Mount the 24 VDC power supply such that dissipated heat does not adversely affect other panel components.

G. Manufacturer(s):

1. Acopian.
2. PULS.
3. Lambda.
4. Equal.

PART 3 EXECUTION

3.01 INSTALLATION

A. The panels shall be installed at locations as shown on the Contract Drawings.

B. Refer to Section 13300.

3.02 TESTS

A. Refer to Section 13300.

END OF SECTION
PART 1 GENERAL

1.1 SCOPE OF WORK

A. Furnish all labor and materials required and installed complete as shown on the Drawings and as specified herein.

B. This Section covers the furnishing, installation, and services for the field-mounted instruments as detailed on the Drawings.

C. Accessories

1. All mounting hardware required for pipe stand, surface, or other mounting shall be provided.

2. Each instrument shall be provided with a manufacturer-installed stainless steel tag identifying the instrument tag number.

PART 2 PRODUCTS

2.1 ULTRASONIC LEVEL/DIFFERENTIAL LEVEL METER

A. Transducer

1. Type

   a. Non-contact, ultrasonic level transducer.

2. Function/Performance

   a. Measuring Range: Transducer range shall be suitable for the installation indicated on the Drawings, up to 50 ft (15m).

   b. Temperature Range: –20 to 60 degrees C.

   c. Relative Humidity: Zero to 100 percent.

   d. Temperature Compensation: Transducers shall be provided with integral temperature sensors for temperature compensation at temperature ranges from -50° to 150° C.

3. Physical

   a. Transducers shall be potted/encapsulated in a Kynar or other chemical and corrosion-resistant housing. Where indicated on the Drawings, transducers shall be approved for installation in Class I, Division 1, Groups C and D (Zone 0) environments.

   b. The surface of transducers shall be Teflon-coated where mounted on chemical tanks and exposed to vapors in the tanks that are not compatible with the transducer material.
c. Transducers shall be capable of being completely submerged without damage.

d. Transducers shall be suitable for surface, pipe, or flange mounting as indicated on the Drawings or Instrument Device Schedule. Appropriate mounting hardwired shall be provided. Flanges shall be six inch (150 mm) and resistant to attack by the medium being metered or, where required, shall be protected by corrosion-resistant coatings and facings.

4. Options/Accessories Required

a. Transducers located in areas where freezing condensation may occur shall be provided with special heaters or other type of transducer protection designed to prevent sensor icing.

b. Signal cable as recommended by the manufacturer, for installation between the transducer(s) and the transmitter. Length, up to 1200 feet (365 m), shall be as required by installation indicated on the Drawings.

5. Manufacturer(s)

a. Siemens-Milltronics.

b. Or Equal.

B. Transmitter/Converter

1. Type

a. Microprocessor based compatible with the transducer(s) provided.

2. Functional/Performance

a. Resolution (including transducer): Plus or minus 0.1 percent of range or 0.08 inches (2 mm), whichever is greater.

b. Accuracy (including transducer): Plus or minus 0.25 percent of range or 0.24 inches (6 mm).

c. Range: As required by the installation indicated on the Drawings.

d. Temperature Range: -20 to 50 degrees C.

e. Output: Two isolated 4-20 mA output and one, three, or six alarm contacts adjustable to trip at any point in the instrument range. Output contacts shall be rated 5 A at 230 VAC.

f. Temperature Compensation: Compensation over the temperature range of the sensor.

g. Display: Digital indicator displaying level/differential level or volume in engineering units or percent as indicated on the Drawings or in the Instrument Device Schedule.
h. Diagnostics: On-screen instructions and display of self-diagnostics.

i. Loss of Signal: Transmitter shall ignore momentary loss-of-echo signals and shall indicate loss of echo on the transmitter unit.

j. Configuration Protection: Programmable parameters shall be protected using E2PROM. Battery backup protection is not acceptable.

3. Physical

a. Transmitter shall be suitable for surface or pipe stand mounting.

b. Enclosure shall be NEMA 4X (IP65).

c. A/C power will be as specified in Section (40 9000) (13300).

4. Accessories Required

a. Hand-held programmer where required for configuration and calibration of the instrument.

5. Manufacturer(s)

a. Siemens Model HydroRanger 200

b. Or Equal.

PART 3 EXECUTION

END OF SECTION
A. **GENERAL**

1. **Scope of Work**

   a. The CONTRACTOR shall furnish all labor, materials, equipment and incidentals required to install, ready for operation and field test stainless steel slide, channel, and downward opening weir gates and appurtenances as shown on the plans and as specified herein.

   b. The gates and appurtenances shall be supplied in accordance with the latest edition of AWWA C561 Standard for Fabricated Stainless Steel Slide Gates as modified herein. The allowable leakage rate for the stainless steel gates in this specification shall be 1/2 the allowable leakage listed in the latest revision of AWWA C561.

2. **Submittals**

   a. Provide the following information to confirm compliance with the specification in addition to the submittal requirements.

      1. Complete description of all materials including the material thickness of all structural components of the frame and slide.

      2. Installation drawings showing all details of construction, details required for installation, dimensions and anchor bolt locations.

      3. Maximum bending stress and deflection of the slide under the maximum design head.

      4. The location of the company headquarters and the location of the principle manufacturing facility. Provide the name of the company that manufactures the equipment if the supplier utilizes an outside source.

3. **Quality Assurance**

   a. **Qualifications**

      1. All of the equipment specified under this Section shall be furnished by a single manufacturer with a minimum of 5 years’ experience designing and manufacturing water control gates. The manufacturer shall have manufactured water control gates for a minimum of 100 projects.
2. The specification is based on the Stainless Steel Gates RW Gates, RW1000-S Slide Gate, equivalent Whipps, Inc. or approved equal.

3. The sizes and types of gates, as well as the type of actuator, shall be as shown on the gate schedule. Floor stand shall be 316 stainless steel mounted on yoke. The gates shall have self-contained, wall mounted frames as shown. Non self-contained frames are not acceptable.

B. EQUIPMENT

1. General

a. Gates shall be as specified herein and have the characteristics and dimensions shown on the Contract Drawings.

<table>
<thead>
<tr>
<th>Description:</th>
<th>Location:</th>
<th>Operator Type</th>
<th>Reference Drawings:</th>
</tr>
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<tbody>
<tr>
<td>North Wet Well Isolation Self-contained Slide Gate</td>
<td>Lift Station Structure</td>
<td>Manual Operated with Removable Handwheel and 2” Square Nut for Portable Operator</td>
<td>Drawing Sheets 12-15</td>
</tr>
<tr>
<td>South Wet Well Isolation Self-contained Slide Gate</td>
<td>Lift Station Structure</td>
<td>Manual Operated with Removable Handwheel and 2” Square Nut for Portable Operator</td>
<td>Drawing Sheets 12-15</td>
</tr>
<tr>
<td>Wet Well Crossover Self-contained Slide Gate</td>
<td>Lift Station Structure</td>
<td>Manual Operated with Removable Handwheel and 2” Square Nut for Portable Operator</td>
<td>Drawing Sheets 12-15</td>
</tr>
<tr>
<td>Influent Cut Off Vault Self-contained Slide Gate</td>
<td>Influent Cut Off Vault</td>
<td>Manual Operated with Removable Handwheel and 2” Square Nut for Portable Operator</td>
<td>Drawing Sheet 11</td>
</tr>
</tbody>
</table>

b. Leakage shall not exceed 0.05 gpm/ft of wetted seal perimeter in seating head and unseating head conditions.

c. The gate shall utilize self-adjusting seals. Due to the difficulty of accessing gates when they are in service, gates that utilize adjustable wedges, wedging devices or pressure pads are not acceptable.

d. All structural components of the frame and slide shall be fabricated of stainless steel having a minimum thickness of 1/4-inch and shall have adequate strength to prevent distortion during normal handling, during installation and while in service.
e. All welds shall be performed by welders with AWS certification.

f. Finish: Mill finish on stainless steel. Welds shall be passivated in accordance with ASTM A380 to remove weld burn and scale. All iron and steel components shall be properly prepared and shop coated with a primer.

g. Materials:

<table>
<thead>
<tr>
<th>Components</th>
<th>Materials</th>
</tr>
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<tbody>
<tr>
<td>Frame Assembly and Retainers</td>
<td>Stainless Steel, Type 316L, ASTM A240</td>
</tr>
<tr>
<td>Slide and Stiffeners</td>
<td>Stainless Steel, Type 316L, ASTM A240</td>
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<td>Stem</td>
<td>Stainless Steel, Type 316, ASTM A276</td>
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<tr>
<td>Fasteners, Nuts and Bolts</td>
<td>Stainless Steel, Type 316, ASTM A276</td>
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<td>Invert Seal (Upward Opening Gates Only)</td>
<td>Neoprene ASTM D-2000 or EPDM</td>
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<td>Seats/Seals and Facing</td>
<td>Ultra-High Molecular Weight Polyethylene</td>
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<td>ASTM D4020</td>
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<tr>
<td>Lift Nuts</td>
<td>Bronze ASTM B584</td>
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<tr>
<td>Pedestals and Wall Brackets</td>
<td>Stainless Steel, Type 316L, ASTM A276</td>
</tr>
<tr>
<td>Operator Housing</td>
<td>ductile iron</td>
</tr>
</tbody>
</table>

2. Frame

a. The frame assembly, including the guide members, invert member and yoke members, shall be constructed of formed stainless steel plate with a minimum thickness of 1/4-inch.

1. Frame design shall allow for mounting directly to a wall with stainless steel anchor bolts and grout or mounting to a wall thimble with stainless steel mounting studs and a mastic gasket material. Wall mounted gates shall have guides that have a minimum weight of 13 lbs per foot. Guide extensions shall be C or Z channel shaped and shall have a minimum weight of 6.5 lbs per foot. Angles are not acceptable guide extensions. The portion of the frame, where the anchors or wall thimble studs penetrate, shall have a minimum thickness of 1/2-inch. Frames shall be outfitted with lifting lugs for handling and installation. Mounting style shall be as shown on the Contract Drawings.

2. All wall mounted or wall thimble mounted gates shall have a flange frame. Flat frame gates are not acceptable.

3. The structural portion of the frame that incorporates the seat/seals shall be formed into a one-piece shape for rigidity. Guide members that consist of two or more bolted structural members are not acceptable. Guide member designs where water loads are transferred through the assembly bolts are specifically not acceptable.
4. Gussets shall be provided as necessary to support the guide members in an unseating head condition. The gussets shall extend to support the outer portion of the guide assembly and shall be positioned to ensure that the load is transferred to the anchor bolts or the wall thimble studs.

5. The frame shall extend to accommodate the entire height of the slide when the slide is in the fully closed or fully opened position.

6. On self-contained gates, a yoke shall be provided across the top of the frame. The yoke shall be formed by two structural members of the C-channel shape affixed to the top of the side frame members to provide a one-piece rigid assembly. Angles are not acceptable as yoke members. The yoke shall be designed to allow removal of the slide.

7. A rigid stainless steel invert member shall be provided across the bottom of the opening. The invert member shall be of the flush-bottom type.

8. A rigid stainless steel top seal member shall be provided across the top of the opening.

3. Slide

   a. The slide and reinforcing stiffeners shall be constructed of stainless steel plate. All structural components shall have a minimum thickness of 1/4-inch.

      1. The slide shall not deflect more than 1/360 of the span or 1/16 inch, whichever is smaller, under the maximum design head. The portion of the slide that engages the frame shall have a minimum thickness of 1/2-inch.

      2. When the width of the gate opening multiplied by the maximum design head dictates a more substantial gate design, the portion of the slide that engages the guide members shall be of a “thick edge” design. The thick edge portion of the slide that engages the guide shall have a minimum thickness of 3 inches.

      3. Reinforcing stiffeners shall be welded to the slide and mounted horizontally. Two vertical stiffeners shall be welded on the outside of the horizontal stiffeners for additional reinforcement.

      4. The stem connector shall be constructed of two angles or plates. The stem connector shall be welded to the slide. A minimum of two bolts shall connect the stem to the stem connector.
4. Seals

a. All gates shall be provided with a self-adjusting seal system to restrict leakage in accordance with the requirements listed in this specification.

1. All gates shall be equipped with UHMW polyethylene seat/seals to restrict leakage and to prevent metal to metal contact between the frame and slide.

2. The seat/seals shall extend to accommodate the 1-1/2 x the height of the slide when the slide is in the fully closed or fully opened position.

3. All slide gates shall be provided with a resilient seal to seal the bottom portion of the gate. The seal shall be attached to the invert member of the frame or the bottom of the slide and it shall be held in place with stainless steel attachment hardware.

4. The seal system shall be durable and shall be designed to accommodate high velocities and frequent cycling without loosening or suffering damage.

5. All seals must be bolted or otherwise mechanically fastened to the frame or slide. Arrangement with seals that are force fit and/or held in place with adhesives are unacceptable.

6. The seals shall be mounted so as not to obstruct the water way opening.

7. Gates that utilize rubber “J” seals or “P” seals are not acceptable.

8. The seal system shall have been factory tested to confirm negligible wear (less than 0.01”) and proper sealing. The factory testing shall consist of an accelerated wear test comprised of a minimum of 25,000 open-close cycles using a well-agitated sand/water mixture to simulate fluidized grit.

5. Stem

a. A threaded operating stem shall be utilized to connect the operating mechanism to the slide. On rising stem gates, the threaded portion shall engage the operating nut in the manual operator or motor actuator. On non-rising stem gates, the threaded portion shall engage the nut on the slide.

1. The threaded portion of the stem shall have a minimum outside diameter of 2 inches. Stem extension pipes are not acceptable.
2. The stem shall be constructed of solid stainless steel bar for the entire length, the metal having a tensile strength of not less than 60,000 psi.

3. The stem shall be threaded to allow full travel of the slide unless the travel distance is otherwise shown on the Contract Drawings.

4. Maximum L/R ratio for the unsupported part of the stem shall not exceed 200.

5. In compression, the stem shall be designed for a critical buckling load caused by a 40 lb effort on the crank or handwheel with a safety factor of 2, using the Euler column formula.

6. The stem shall be designed to withstand the tension load caused by the application of a 40 lb effort on the crank or handwheel without exceeding 1/5 of the ultimate tensile strength of the stem material.

7. The threaded portion of the stem shall have machine rolled, full depth Acme threads with a 16 microinch finish or better. Stub threads are not acceptable.

8. Stems of more than one section shall be joined by stainless steel or bronze couplings. The coupling shall be bolted to the stems.

9. Stems, on manually operated gates, shall be provided with adjustable, internally threaded bronze stop collars with a stainless steel set screw to prevent over closing of the slide.

6. Stem Guides

   a. Stem guide shall be provided when necessary to ensure that the maximum L/R ratio for the unsupported part of the stem is 200 or less.

      1. Stem guide brackets shall be fabricated of stainless steel and shall be outfitted with UHMW or bronze bushings.

      2. Adjustable in two directions.

7. Manual Operators

   a. Gates shall be operated by a manual handwheel or a manual crank-operated gearbox (see schedule). The operator shall be mounted on the yoke of self contained gates or on the pedestal of non-self contained gates.
1. The gate manufacturer shall select the proper gear ratio to ensure that the gate can be operated with no more than a 40 lb effort when the gate is in the closed position and experiencing the maximum operating head.

2. An arrow with the word "OPEN" shall be permanently attached or cast onto the operator to indicate the direction or rotation to open the gate.

3. Handwheel operators shall be fully enclosed and shall have a cast aluminum housing.
   a. Handwheel operators shall be provided with a threaded cast bronze lift nut to engage the operating stem.
   b. Handwheel operators shall be equipped with roller bearings above and below the operating nut.
   c. Positive mechanical seals shall be provided above and below the operating nut to exclude moisture and dirt and prevent leakage of lubricant out of the hoist.
   d. The handwheel shall be removable and shall have a minimum diameter of 15 inches.

4. Crank-operated gearboxes shall be fully enclosed and shall have a cast aluminum or ductile iron housing.
   a. Gearboxes shall have either single or double gear reduction depending upon the lifting capacity required.
   b. Gearboxes shall be provided with a threaded cast bronze lift nut to engage the operating stem.
   c. Bearings shall be provided above and below the flange on the operating nut to support both opening and closing thrusts.
   d. Gears shall be steel with machined cut teeth designed for smooth operation.
   e. The pinion shaft shall be stainless steel and shall be supported on ball or tapered roller bearings.
   f. Positive mechanical seals shall be provided on the operating nut and the pinion shafts to exclude moisture and dirt and prevent leakage of lubricant out of the hoist.
   g. The crank shall be cast aluminum or cast iron with a revolving nylon grip.
   h. The crank shall be removable.

5. An extended operator system utilizing chain and sprockets shall be furnished by the manufacturer when the centerline of the crank or handwheel, on a non-
geared operator, is located over 48-in above the operating floor. Chain wheels are not acceptable.

a. A removable stainless steel or aluminum cover shall be provided to enclose chain and sprockets.
b. The extended operator system shall lower the centerline of the pinion shaft to 36-in above the operating floor.
c. A handwheel may be utilized in conjunction with a gearbox in lieu of the extended operator system if the centerline of the pinion shaft is 60-in or less above the operating floor.

6. Pedestals shall be constructed of stainless steel. Aluminum pedestals are not acceptable.

a. The pedestal height shall be such that the electric actuator, handwheel or pinion shaft on the crank-operated gearbox is located approximately 36-in above the operating floor. The base plate and adaptor plate on the pedestal shall have a minimum thickness of 1/2-inch. The base plate shall bolt directly to the yoke of the frame where shown on the Contract Drawings.
b. Wall brackets shall be used to support floor stands where shown on the Drawings and shall be constructed of stainless steel.
c. Wall brackets shall be reinforced to withstand in compression at least two times the rated output of the operator with a 40 lb effort on the crank or handwheel.
d. The design and detail of the brackets and anchor bolts shall be provided by the gate manufacturer and shall be approved by the ENGINEER. The gate manufacturer shall supply the bracket, anchor bolts and accessories as part of the gate assembly.

7. Operators shall be equipped with fracture-resistant clear butyrate or lexan plastic stem covers.

a. The top of the stem cover shall be closed.
b. The bottom end of the stem cover shall be mounted in a housing or adapter for easy field mounting.
c. Stem covers shall be complete with indicator markings to indicate gate position.

8. When shown on the Contract Drawings, provide 2 inch square nut, mounted in a floor box, with a non-rising stem.

a. The square nut shall be constructed of bronze.
b. The floor box shall be constructed of stainless steel or cast iron and shall be set in the concrete floor above the gate as shown.
c. Provide one aluminum or stainless steel T-handle wrench for operation.

8. Electric Motor Actuators

a. General: The electric actuator shall be of the top mounted configuration and shall include (as one integral unit) but not limited to, the electric motor, reduction gearing, drive bushing or top entry stem nut, torque switches, position limit switches, gear case and auxiliary handwheel. The electric actuator shall be Factory Mutual approved for hazardous locations. The actuator shall be Auma Model SAEX multi turn Actuator or Equal.

1. Gears: Reduction shall be accomplished by means of a two stage gear train consisting of first stage spur of helical and second stage of self-locking worm and worm gear. Gear housing shall be ductile iron. Spur gears and worms shall be steel. Worm gear shall be bronze. Non-metallic gears in power train are not acceptable.

2. Hammer Blow: When required by the unseating application, a lost motion device (independent of gear backlash) shall be supplied integral in the actuator gear train. This device shall allow the motor to attain full speed before the load is encountered.

3. Bearings: All gears and shafting shall be supported on unit-friction bearings. Where thrust is a consideration, tapered roller bearings (to accept thrust) shall be provided.

4. Lubrication: All gearing and bearings shall be grease or oil lubricated. Seals shall be provided at all exit points of the gear case to prevent leakage of lubricant. Critical area subject to high wear shall be double sealed. Lubricants shall be suitable for year-round service based on ambient temperature conditions. Special attention should be paid to environments with temperatures below 0 F.

5. Handwheel: The actuator shall be equipped with a handwheel for manual operation, so connected that operation by the motor shall not cause the handwheel to rotate. Should power be returned to the motor while the handwheel is in use, the design of the unit shall prevent transmission of the motor torque to the handwheel. Use of the handwheel shall not negate the hammer-blow feature. The handwheel shall require an effort of no more than 80 pounds on the rim for seating or unseating load, or 60 pounds for running load. The handwheel shall have an arrow and the word "Open" indicating required
rotation. The handwheel shall operate in the clockwise direction to close. External declutch lever will be padlockable in either the manual (handwheel) or motor mode.

6. Motor: Electric motors shall be specially designed for valve actuator service, and shall be totally enclosed nonventilated. As a minimum, the electric motor enclosure shall meet NEMA 4 weatherproof construction. When specified, motor enclosure(s) shall be available to meet submersible NEMA 6 or NEMA 7 explosion proof Class 1, Group D, Div. 1 or 2 requirements. Motors shall be capable of operating through one complete cycle, open-close-open or under the maximum specified operating conditions when voltage to the motor is + or - 10 percent of the specified voltage. Motors shall have a Class F insulation with Class B temperature rise. Overload protection shall be by means of inherent motor thermal sensors embedded in the windings.

7. Limit Switches: Open and close limit switches shall be geared to the drive mechanism and in step at all times, whether the unit is operated electrically or manually. The switches shall be of the rotary drum wiping action contact type, field adjustable, and capable of being set either fully open, fully closed, or at any intermediate point. Limit switch contacts shall be solid silver and have a minimum rating of 10 amps (break) inductive at 120 VA-c. Limit switch gearing shall be grease lubricated. The drive mechanism shall be totally enclosed to prevent entrance of foreign matter. Gears shall be steel. Use of cams or set screws in securing switches or the drive system is unacceptable.

8. Torque Switches: The actuator shall include an adjustable torque (and thrust where applicable) limiting switch arrangement to break the control power circuit when:

9. The valve has reached the stops in the open or close position.

10. An obstruction has been encountered in either direction of travel. Open and close torque switches shall be adjustable by means of individually calibrated dials (marked open and close).

11. Electrical Controls Enclosures (Switch Compartment): Terminal strips, space heater, limit and torque switches, as well as optional electrical accessories, shall be prewired and supplied in a modular form (modular control package-MCP), housed in a single switch compartment meeting NEMA 4 weatherproof construction. Enclosures shall be flange to flange with O-ring seal and hinged. Cover bolting shall be stainless steel and captive.
12. Stem Coupling: For applications which require coupling to a shaft and key, a steel drive bushing properly bored and keyed shall be supplied. Stem coupling for threaded stem applications shall be accomplished by means of a high tensile, bronze alloy stem nut. The nut shall of the top entry 2-piece design, permitting installation and removal without disassembly of the actuator or disconnecting the electrical wiring conduit.

13. Position Indication: Position indication shall be accomplished by means of an indicator dial in full step at all times with valve travel, whether in power or manual operation. The indicator dial shall be graduated in 25 percent increments as a minimum; closed, quarter open, half open, three-quarter open, and open.

14. Stem Protectors: Stem protectors for rising threaded stem applications shall be supplied by the gate manufacturer or contractor in suitable length and diameter to allow for full extension of the stem. Stem covers shall couple to the top of the actuator by means of a national pipe thread NPT and shall be capped to prevent the entrance of foreign matter and precipitation.

15. Electrical Controls: Electrical controls, shall be pre-mounted and wired as part of the Modular Control Package (MCP), and shall include but not be limited to reversing contactor, control power transformer, open-stop-close push buttons, and position indication light(s) (for open-close and throttling service), control power transformer, open-stop-close push buttons, indicating light(s), feedback potentiometer, and local-off-remote selector switch:

a. Reversing Contactor: Control voltage shall be 120 volts, single phase, 60 Hz. Seal-in latching contacts shall be supplied for use in the push button circuits. When specified, additional auxiliary contacts (1 N.O. and 1 N.C.) shall be supplied. Starter shall be both electrically and mechanically interlocked.

b. Control Power Transformer. Transformer shall be designed to transform 230 or 460 volts, three phase, 60Hz power to 120 volts, single phase. The transformer shall be complete with a grounded and fused secondary.

c. Push Buttons: Each actuator shall be supplied complete with open-stop-close push buttons. Push buttons shall be furnished integral. As a minimum, the remote enclosure shall meet NEMA 4 weatherproof construction. When specified, the remote enclosures shall be available to meet submersible or NEMA 7 explosion-proof requirements.

d. Indication Light(s): Each actuator shall be furnished complete with open-close light indication for valve position. Lenses shall be red for open and green for close. Both lamps shall be lit during intermediate travel. Light(s)
shall be mounted integral or in the separate remote push button enclosure when specified.

e. Reversing Contactor: Seal-in latching contacts shall not be supplied for the selector switch remote position.

f. Feedback Potentiometer: Feedback potentiometer shall be specifically selected for compatibility with the position comparator circuit supplied. The potentiometer shall be mechanically connected to the valve stem and in step at all times whether the unit is being operated electrically or by handwheel.

g. Selector Switch: A local-off-remote selector switch function shall be supplied to isolate the incoming process signal control function from the manual push button controls. The selector switch shall be padlockable in all three positions.

h. Position Comparator Circuit: The position comparator circuit shall be of solid state printed circuit board design and shall include (but not limited to) a zero, span and deadband adjustment. LED lamps shall be furnished for indication of control status. Positioning of the valve should be accomplished by comparing the input from the feedback potentiometer with an incoming process control signal. Process control signal shall be 4-20 MA or as specified by the purchaser.

i. All integral electrical components shall be shop-wired to a terminal strip(s) to facilitate a minimum of field wiring at the time of installation.

j. Position Transmitter: A position potentiometer (independent of feedback potentiometer in the case of modulating service) shall be supplied when continuous valve position signal is required. It shall be mechanically connected to the valve stem and in step at all times whether the unit is being electrically or handwheel operated.

9. Anchor Bolts

a. Anchor bolts shall be provided by the gate manufacturer for mounting the gates and appurtenances.

1. Quantity and location shall be determined by the gate manufacturer.

2. If epoxy type anchor bolts are provided, the gate manufacturer shall provide the studs and nuts.
3. Anchor bolts shall have a minimum diameter of 1/2-inch.

C. EXECUTION

1. Installation

   a. Installation of the slide gates and appurtenances shall be done in a workmanlike manner. It shall be the responsibility of the CONTRACTOR to handle, store and install the equipment specified in this Section in strict accordance with the manufacturer's recommendations.

   b. The CONTRACTOR shall review the installation drawings and installation instruction prior to installing the gates.

   c. The slide gate assemblies shall be installed in a true vertical plane, square and plumb.

   d. The CONTRACTOR shall fill the void in between the gate frame and the wall with non-shrink grout as shown on the installation drawing and in accordance with the manufacturer’s recommendations.

   e. Contractor to apply a finish coat of paint to the manual gearbox housings after installation of the gate assembly.

2. Field Testing & Training

   a. After installation, all gates shall be field tested in the presence of the ENGINEER and OWNER to ensure that all items of equipment are in full compliance with this Section. Each gate shall be cycled to confirm that they operate without binding, scraping, or distorting. The effort to open and close manual operators shall be measured, and shall not exceed the maximum operating effort specified above. Electric motor actuators shall function smoothly and without interruption. Each gate shall be water tested by the CONTRACTOR, at the discretion of the ENGINEER and OWNER, to confirm that leakage does not exceed the specified allowable leakage.

   b. See Special Conditions 1.16 Manufacturer’s start-up, certifications & training requirements for additional details and requirements.

END OF SECTION
PART 1 - GENERAL

1.1 SUMMARY

A. Underhung, single girder bridge crane. 2-ton, 24’-6” span with motorized hoist, bridge, and trolley.

B. Pre-engineered steel support frame and concrete support footings conforming to layout and height dimensions generally shown on construction drawings.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. American Bearing Manufacturers Association (ABMA).

2. American Society of Mechanical Engineers (ASME):

3. ASTM International (ASTM):

   a. 70, National Electrical Code (NEC).

B. Comply with ASME B30.11 and ASME B30.16.

1.3 DEFINITIONS

A. Hook Height: The minimum acceptable distance in feet from bottom of hook in full raised position to the nearest floor surface.

B. Lift Height: The distance in feet from the bottom of the hook in full raised position to the surface of the lowest floor from which items may be hoisted.

C. Total Trolley Capacity: The ultimate load-carrying capacity of the trolley based on the ultimate strength of the material used (with a 5:1 safety factor) and the bearing life.

D. Ultimate Load-Carrying Capacity: Live load, weights of all equipment and an allowance for impact.
1.4 SUBMITTALS

A. Shop Drawings:

1. Product technical data including:
   a. Acknowledgement that products submitted meet requirements of standards referenced.

2. Design information, fabrication and/or layout drawings shall be prepared, signed and sealed by a Professional Engineer registered in the State of Oklahoma. The design submittal information shall include:
   a. Concrete footing design information and dimensional drawings.
   b. Steel support frame design information, layout and dimensional drawings.
   c. Anchor bolt design information, layout and dimensional drawings.
   d. Track layout including supports, splices, connections, switches, and end trucks.

3. Test reports verifying strength of inserts and rail.

4. Load test results.

B. Contract Closeout Information:

1. Operation and Maintenance Data.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. Hoists:
   a. Konecranes
   b. Yale.
   c. Coffing WR.
   d. Shaw Box
2. Trolleys:
   a. Konecranes
   b. Yale.
   c. Coffing.
   d. Shaw Box

2.2 MANUFACTURED UNITS

A. Trolleys:
   1. Completely compatible with hoists, cranes, and monorails specified.
   2. Meet NEC standards according to classifications shown on Drawings.
   3. Minimum ABMA L-10 bearing life of 5000 HRS based on 75 percent of the wheel load, excluding impact.
   4. Motor Driven:
      a. Operate at 3 000/ r/min synchronized speed, 2 680/ r/min nominal speed.
      b. Enclose internal gears in oil tight housing.
      c. Design motors to operate with 460 V, 0.4hp.

B. Hoists:
   1. Electric wire rope hoists:
      a. CXT – wire rope hoists by Konecranes or equal.
      b. Low headroom models.
      c. Hoist frames of welded heavy steel plate construction.
      d. Oil tight gear casing for oil bath lubrication of gears.
      e. Construct rope drum and surrounding units to minimize abrading, crushing or jamming of the rope during usage.
      f. Drum diameter not less than 18 times the diameter of the rope used.
g. Assure that two (2) complete wraps of rope remain on the drum after lowering the load hook through its rated lift distance, unless a lower limit device is provided, in which case provide a minimum of one (1) complete wrap.

h. Double revving for hoists with total lift height greater than hook height.

i. Sheave and drum grooves: Smooth and free from surface irregularities which could cause rope damage.

j. Provide running sheaves with means for lubrication.

k. Bearings:
   1) Antifriction type.
   2) Minimum ABMA L-10 life of 1250 HRS for Class H1, 2500 HRS for Class H2, and 5000 HRS for Class H3, based on full rated speed and mean effective load K of 0.65.

l. Mechanical load brake.

m. Lower limit switch to stop hoist when hook reaches its lower limit.

n. Motor:
   1) Motor brake.
      a) Internal disc magnetic type.
      b) Rated for 150 percent of motor torque.
   2) TENV motors operable on 460 V, 3 PH, 60 cycle power.
   3) Meet specified area classification.
   4) Permanently lubricate and seal motor ball-bearings.
   5) Provide an upper limit switch to stop the hoist motor and apply the holding brake when the hook reaches its upper limit.

o. Mark the hoist with the following information:
   1) Name and address of manufacturer.
2) Manufacturer's unit identification number.

3) Rated load.

4) Voltage of AC or DC power supply and phase and frequency of AC power supply.

5) Rated amperage.

2. For Class I, Division 1 or 2, Group D locations, provide spark and corrosion-resistant models with bronze hooks, stainless steel load chains, bronze or aluminum hand chain, and bronze trolley wheels.

3. Mark each hoist with the following information:
   a. Name and address of manufacturer.
   b. Manufacturer's unit identification number.
   c. Rated load.

2.3 ACCESSORIES

A. Trolley stops design to engage the trolley frame rather than trolley wheels.

B. Furnish chain containers for hand hoists.

C. Electrification and Controls:

1. Provide electrical power to the motor-driven hoists and trolleys using one (1) of the following methods as scheduled:

   a. Festoon tagline system:

      1) Equip with plastic wheels in areas with an NEC classification of Class I, Division 1 or 2, Group D.

      2) Include all components needed for a complete and operable system.

   b. Cable reel system:

      1) 360-degree swivel base.

      2) Full working length of cable plus 25 percent.
3) Include all components needed for a complete and operable system.

2. Controls:
   a. Pendant pushbutton control stations with reversing type contactors for electric hoists and/or trolleys.
   b. Single station if hoist and trolley are both motor-driven.
   c. Suspend control stations from trolleys.
   d. Clearly mark function of each button.
   e. Suspend station in a manner that will protect the electrical conductors against strain.
   f. Control station: Operable from 115 V power supply.
   g. Ground control station to hoist.
   h. Provide control cable lengths of 1 FT less than distance to nearest floor.
   i. Provide two-speed or variable speed control for hoists and trolleys.

3. Switches:
   b. Completely compatible with hoists, trolleys, and monorails specified.
   c. Provide switch chain to within 6 FT of floor.

PART 3 - EXECUTION

3.1 INSTALLATION
   A. Fabricate and construct structural steel support frame
   B. Arrange supports for easy removal of bridge for repair or replacement.
   C. Align bridge and runway tracks true and level.
   D. Warning Signs:
1. Affix to the hoist or the lower load block or the controls in a readable position a durable label or labels displaying the following information concerning safe operating procedures:
   
a. The word WARNING or other legend designed to bring the label to the attention of an operator.

   b. Cautionary language against:
      
      1) Lifting more than rated load.
      2) Operating hoist when hook is not centered under hoist.
      3) Operating hoist with twisted, kinked or damaged rope or chain.
      4) Operating damaged or malfunctioning hoist.
      5) Operating hoist with a rope that is not properly seated in its groove (if applicable).
      6) Lifting people or lifting loads over people.
      7) Removing or obscuring warning label.

3.2 FIELD QUALITY CONTROL

A. Test using 110 percent rated load.

B. Employ and pay for services of equipment manufacturer's field service representative(s) to:
   
   1. Inspect equipment covered by this Specification Section.
   2. Supervise pre-start-up adjustments, installation checks and all field tests.
   3. Conduct initial start-up of equipment and perform operational checks.
   4. Provide a written statement that manufacturer's equipment has been installed properly, started up and is ready for operation by Owner's personnel.
   5. Instruct Owner's personnel for 8 HRS at jobsite on operation and maintenance of the hoist, trolley, monorail and crane equipment.
3.3 SCHEDULE

A. Hoist, trolley, and bridge systems include but are not necessarily limited to the following:

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>LOADING (TONS)</th>
<th>HOIST</th>
<th>TROLLEY</th>
<th>HOOK HEIGHT (FT)*</th>
<th>LIFTING HEIGHT (FT)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northside Lift Station Structure</td>
<td>2</td>
<td>WR</td>
<td>HG</td>
<td>13’-6”</td>
<td>45’-0”</td>
</tr>
</tbody>
</table>

* Distances listed are approximate as they will vary depending on hoist and trolley selection.

C = Chain  
HG = Hand Geared  
WR = Wire Rope  
NA = Not Applicable

END OF SECTION
MAGNETIC FLOW METERS

15.3 - 1

A. GENERAL

1. Scope of Work
   a. This specification section covers the work necessary to furnish magnetic flow meters for installation as shown on the plans.
   b. Flow meter components shall be of the same manufacturer to obtain standardization of performance, operation, spare parts, maintenance and manufacturer's services.

2. Delivery and Handling
   a. Equipment shall be delivered to the contractor completely factory assembled. Individual equipment components shall be crated in structurally adequate packing containers to prevent damage during shipping, facilitate easy of handling and to provide suitable protection from weather for extended storage at the jobsite prior to installation. Packing containers shall be permanently labeled with appropriate equipment identification, shipping address and return address. Packing list shall be provided with equipment at time of delivery.
   b. Electrical equipment shall be kept thoroughly dry at all times and shall be stored indoors. Equipment storage shall be protected and maintained in accordance with the manufacturer's recommendations. Equipment shall not be stored directly on the ground.
   c. The contractor shall utilize equipment and tools of adequate size suitable for unloading, transporting, storing and supporting the equipment during installation. Caution shall be employed to prevent equipment damage resulting from abrupt contact with other materials or equipment.

3. Quality Assurance
   a. The magnetic meter type flow meters furnished under this contract shall be as manufactured by Sparling Instruments, Inc. or equal.
   b. The flow meter manufacturer shall submit to the Engineer for his review, certified copies of flow test results for each meter. Test results shall be submitted prior to shipment upon Engineer's request and shall show compliance with specified performance requirements.
4. Warranty

a. The manufacturer shall warrant the equipment to be of quality construction, free from defects in materials and workmanship. The warranty shall become effective upon acceptance by the Owner or Owner's authorized agent.

b. The equipment, apparatus, and parts furnished shall be warranted for a period of one (1) year, excepting only those items that are normally consumed in service, such as light bulbs, fuses, oil, grease, packing, gaskets, O-rings, etc. The manufacturer shall be solely responsible for the warranty of the equipment and all components.

c. Upon request from the Engineer and/or the Owner, the manufacturer shall demonstrate proof of financial responsibility with respect to performance and delivery date. In addition, the manufacturer shall provide proof of evidence of facilities, equipment, and skills required to produce the equipment specified herein and provide technical service and replacement parts.

d. Components failing to perform as specified by the Engineer, or as represented by the manufacturer, or proven defective in service during the warranty period, shall be replaced, repaired, or satisfactorily modified by the manufacturer without cost of parts or labor to the Owner.

e. The manufacturer shall provide an application performance guarantee with submittals.

5. Description

A. Quantity: One (1) 12" magnetic flow meter  
One (1) 16" magnetic flow meter

B. Operating Characteristics

<table>
<thead>
<tr>
<th>Meter Name</th>
<th>Low Flow</th>
<th>Normal Range</th>
<th>Max Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>12&quot;</td>
<td>200 GPM</td>
<td>650 GPM</td>
<td>2000 GPM</td>
</tr>
<tr>
<td>16&quot;</td>
<td>400 GPM</td>
<td>1900 GPM</td>
<td>5000 GPM</td>
</tr>
</tbody>
</table>

Maximum Working Pressure 150 PSIG
B. MATERIALS

1. Description

a. The magnetic flow meter shall utilize DC bi-polar pulsed coil excitation, automatically re-zeroing after every cycle.

b. The meter shall incorporate HI-Z circuitry. The preamplifier input impedance shall not be less than \(10^{12}\) ohms. External ultrasonic electrode cleaners shall not be acceptable.

c. Available outputs shall be 1) Isolated analog 4-20 milliamp DC into 800 ohms standard; 2) scaled pulse 24 VDC with selectable 12.5/25/50/100 millisecond on time, maximum frequency 60 Hz; 3) 0-1000 Hz frequency, for 0-100% flowrate, 15 VDC; 4) two flow alarms; 5) fault, with open collector; 6) RS232 communications; 7) flow direction with open collector; 8) Positive Zero Return (PZR) for external relay contacts. Outputs 2 & 3 can be open collector if required.

d. Low flow cutoff shall be adjustable from 0 - 9% full scale and there shall be two flow alarms individually programmable from 0-99% of span.

e. The flow meter shall incorporate the MAG-COMMAND™ feature allowing menu selection and changes to be made from outside the housing via Hall-effect sensors. It shall not be necessary to remove covers, panels or fasteners to accomplish calibration or program changes.

f. The meter software shall incorporate a password feature preventing inadvertent program changes.

g. The meter shall feature dedicated non-volatile sensor memory (EEPROM) which shall contain all the characteristics of the sensor (i.e. calibration factors, coil frequency, gain settings) as well as user defined parameters on site. This memory shall facilitate automatic transfer of pre-programmed data to new electronics in the event of a transmitter fault, without requiring renewed calibration/ programming. The program shall retain all data for a period of 10 years without any battery power.

h. Totalized flow and programmed configuration shall be maintained in memory for at least 10 years.

i. The flow meter shall have a switching power supply having an input voltage range from 77 - 265 VAC 50/60 Hz (12-60 VDC). Power consumption shall not exceed 20 Watts.
MAGNETIC FLOW METERS

15.3 - 4

j. All printed circuit boards shall be contained in a plug-in module and be interchangeable for any size without requiring test equipment.

k. The flow meter shall have a diagnostic feature which will provide a display message and fault output in case of a sensor failure, programming error or empty pipe condition.

2. Accuracy

a. The accuracy shall be at least 0.5% of flowrate over a 33:1 turndown at all flow rates above 1 fps. Accuracy shall be verified by calibration in a flow laboratory traceable to the U.S. National Institute of Standards and Technology.

3. Construction

a. The flow sensor liner shall be polyurethane.

b. The electronics shall be integral mounted.

c. All printed circuit boards shall be contained in a single easy plug-in, easy plug-out module which is interchangeable with EP electronics from any size meter without requiring any testing or programming.

d. The meter shall incorporate an EEPROM located in the sensor body which will upload meter calibration into the electronic module upon power up, eliminating any reprogramming from an electronic module change.

e. A 2 line, 16 character backlit alphanumeric display shall indicate user-defined flow units and total flow. All menu advice and commands shall be visible on this display. Characters shall be at least 0.125" high for ease of readability.

f. The display shall be modular and rotatable 360° in 90° increments.

g. The flow meter electrodes shall be stainless steel standard.

h. The flow meter shall be inherently bi-directional and capable of measuring in both directions and keeping track of flow in both directions. The flow meter shall have the ability to totalize in either direction or sum the flow in either direction.

i. The meter ends shall be provided with 150 lb flanges.
4. Approvals/Certifications
   a. The integrally mounted flow sensor and transmitter shall be FM approved for Class I, Division 1, Groups B, C, D and Class II, Division 1, Groups E, F, G environments without use of air purge. CSA approved for Class I, Division 2. Optional Cenelec approval available.

5. Environmental Specifications
   a. The flow meter shall be suitable for operation at temperatures from -40°F to 266°F and at pressures from full vacuum to 740 psi.
   b. The mounted flow sensor furnished with the remote mounted transmitter shall be rated for permanent submergence.

C. INSTALLATION
   1. The contractor shall assume full responsibility for Coordination of the entire project, including verification that all electronic systems and equipment components are compatible. The general contractor shall initially operate each equipment system, and shall make all necessary adjustments so that each system is placed in proper operating condition.
   2. Equipment and materials utilized or supplied for this project must be approved by the Engineer prior to installation. Approval for installation or incorporation in this project will be made only after submittal of manufacturer's shop and installation drawings, test results or other data as required and as specified herein.
   3. Installation of equipment shall be in full conformance with the manufacturer shop drawings and requirements as approved by the Engineer. Wherever a conflict arises between manufacturer’s instructions and the contract documents, the contractor shall follow the Engineer's decision at no additional cost to the owner.
   4. The contractor shall install equipment and materials furnished under this bid in a workmanlike manner utilizing craftsmen skilled in the particular trade. The finished installation shall portray a neat, plumb and clean appearance.

D. FUNCTION OF MANUFACTURER
   1. Provide the services of a representative of the meter manufacturer to assist in adjusting and testing the equipment, to supervise initial operation, and to assist in making final adjustments and the tests specified, or which may be necessary to assure the Engineer that the equipment is in satisfactory operating conditions.
2. Operation and Maintenance Materials

a. The Manufacturer/Supplier shall be responsible for supplying written instruction, which shall be sufficiently comprehensive to enable the operator to service and operate the meter and all equipment supplied by the manufacturer.

b. Operation and maintenance instruction shall be specific to the equipment supplied in accordance with these specifications. Instruction manuals applicable to many different configurations and meters, and which require the operator to selectively read portions of the instructions shall not be acceptable.

End of Section
PART 1 GENERAL

1.01 SCOPE OF WORK

   A.  Furnish all labor, materials and equipment required and install complete and make operational, electrical system as shown on the Drawings and as specified herein.

   B.  The work shall include the following:

        1.  Provide conduit, wire and field connections for all motors, motor controllers, control devices, control panels and electrical equipment furnished under Divisions 1, 11, 13 and 15.

        2.  Provide conduit, wiring and terminations for variable frequency drives, reactors, harmonic filters, transformers and power factor correction capacitors furnished and mounted under other related Divisions.

   C.  Each bidder or their authorized representatives shall, before preparing their proposal, visit all areas of the existing buildings and structures in which work under this sub-bid is to be performed and inspect carefully the present installation.  The submission of the proposal by this bidder shall be considered evidence that their representative has visited the buildings and structures and noted the locations and conditions under which the work will be performed and that he/she takes full responsibility for a complete knowledge of all factors governing his/her work.

1.02 SUBMITTALS

   A.  As a minimum all equipment specified in each Section of Division 16 shall be submitted at one time.  As an example all lighting fixtures shall be submitted together, all motor control centers shall be submitted together, etc.  Submittals that do not comply will be returned disapproved.

   B.  Mark submittals to clearly identify proposed equipment including accessories, options, and features and to exclude parts not applicable to the project. When manufacturer’s cut sheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Each submittal piece of literature and each submittal drawing shall clearly reference the Project Specification and/or Contract Drawing that the submittal is to cover. General catalogs will not be accepted as cut sheets to fulfill submittal requirements.

   C.  Check shop drawings for accuracy prior to submittal.  Shop drawings shall be stamped with the date checked and a statement indicating that the shop drawings conform to this Section and the Drawings.  This statement shall also list all exceptions to this Section and the Drawings.  Mark submittals to identify proposed equipment including accessories, options and features being proposed for approval and exclude parts not to be used.  Shop drawings not so checked and noted shall be returned marked NOT APPROVED.

   D.  The Engineer's check shall be for conformance with the design concept of the project and compliance with this Section and the Drawings.  Errors and omissions on approved shop
drawings shall not relieve the Contractor from the responsibility of providing materials and workmanship required by this Section and the Drawings.

E. All dimensions shall be field verified at the job site and coordinated with the work of all other trades.

F. Material shall not be ordered or shipped until the shop drawings have been approved. No material shall be ordered or shop work started if shop drawings are marked “APPROVED AS NOTED - CONFIRM,” "APPROVED AS NOTED - RESUBMIT" or "NOT APPROVED."

G. Operation and Maintenance Data

1. Submit operations and maintenance data for equipment furnished under this Division, in accordance with Section 01730. The manuals shall be prepared specifically for this installation and shall include catalog data sheets, drawings, equipment lists, descriptions, parts lists including replacement part numbers, to instruct operating and maintenance personnel unfamiliar with such equipment.

2. Manuals shall include the following as a minimum:
   a. A complete "As-Built" set of approved shop drawings.
   b. A complete list of the equipment supplied, including serial numbers, ranges and pertinent data.
   c. Detailed service, maintenance and operation instructions for each item supplied.

H. Exceptions for Submittals

1. Exceptions to the Specifications or Drawings shall be clearly defined by the Electrical Subcontractor in a separate section of each submittal package. The submittal shall contain the reason for the exception, the exact nature of the exception and the proposed substitution so that a proper evaluation may be made by the Engineer. The acceptability of any device or methodology submitted as an “or equal” or “exception” to the Specifications shall be at the sole discretion of the Engineer.

I. Submittals will be returned to the Contractor under one of the following codes.

Code 1 - "APPROVED" is assigned when there are no notations or comments on the submittal. When returned under this code the Contractor may release the equipment and/or material for manufacture.

Code 2 - "APPROVED AS NOTED" - This code is assigned when a confirmation of the notations and comments IS NOT required by the Contractor. The Contractor may release the equipment or material for manufacture; however, all notations and comments must be incorporated into the final product.

Code 3 - "APPROVED AS NOTED/CONFIRM" - This combination of codes is assigned when a confirmation of the notations and comments IS required by the Contractor. The Contractor may, at his own risk, release the equipment or material for manufacture; however, all notations and comments must be incorporated into the final product. This confirmation shall specifically
address each omission and nonconforming item that was noted. Confirmation is to be received by the Engineer within 10 calendar days of the date of the Engineer's transmittal requiring the confirmation.

Code 4 - "APPROVED AS NOTED/RESUBMIT" - This combination of codes is assigned when notations and comments are extensive enough to require a resubmittal of the package. This resubmittal is to address all comments, omissions and non-conforming items that were noted. Resubmittal is to be received by the Engineer within 15 calendar days of the date of the Engineer's transmittal requiring the resubmittal.

Code 5 - "NOT APPROVED" is assigned when the submittal does not meet the intent of the Contract Documents. The Contractor must resubmit the entire package revised to bring the submittal into conformance. It may be necessary to resubmit using a different manufacturer/vendor to meet the Contract Documents.

Code 6 - "COMMENTS ATTACHED" is assigned where there are comments attached to the returned submittal which provide additional data to aid the Contractor.

Code 7 - "RECEIPT ACKNOWLEDGED" - This code is assigned to acknowledge receipt of a submittal that is not subject to the Engineer’s review and approval; and, is being filed for informational purposes only. This code is generally used in acknowledging receipt of means and methods of construction work plan, field conformance test reports, and Health and Safety plans.

Codes 1 through 5 designate the status of the reviewed submittal with Code 6 showing there has been an attachment of additional data.

1.03 REFERENCE STANDARDS

A. Electric equipment, materials and installation shall comply with 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.

1.04 PRIORITY OF THE CONTRACT DOCUMENTS

A. If, during the performance of the work, the Contractor finds a conflict, error or discrepancy between or among one or more of the Sections or between or among one or more Sections and the Drawings, furnish the higher performance requirements. The higher performance requirement shall be considered the equipment, material, device or installation method which represents the most stringent option, the highest quality or the largest quantity.

B. In all cases, figured dimensions shall govern over scaled dimensions, but work not dimensioned shall be as directed by the Engineer and work not particularly shown, identified, sized, or located shall be the same as similar work that is shown or specified.
C. Detailed Drawings shall govern over general drawings, larger scale Drawings take precedence over smaller scale Drawings, Change Order Drawings shall govern over Contract Drawings and Contract Drawings shall govern over Shop Drawings.

D. If the issue of priority is due to a conflict or discrepancy between the provisions of the Contract Documents and any referenced standard, or code of any technical society, organization or association, the provisions of the Contract Documents will take precedence if they are more stringent or presumptively cause a higher level of performance. If there is any conflict or discrepancy between standard specifications, or codes of any technical society, organization or association, or between Laws and Regulations, the higher performance requirement shall be binding on the Contractor, unless otherwise directed by the Engineer.

E. In accordance with the intent of the Contract Documents, the Contractor accepts the fact that compliance with the priority order specified shall not justify an increase in Contract Price or an extension in Contract Time nor limit in any way, the Contractor's responsibility to comply with all Laws and Regulations at all times.

1.05 ENCLOSURE TYPES

A. Unless otherwise required, electrical enclosures shall be NEMA Types as follows:

1. NEMA 4 in outdoor locations, rooms below grade including basements and buried vaults and "WET" locations shown on the Drawings.

2. NEMA 4X in "CORROSIVE" locations shown on the Drawings.

1.06 CODES, INSPECTION AND FEES

A. Equipment, materials and installation shall comply with the requirements of the local authority having jurisdiction.

B. Obtain all necessary permits and pay all fees required for permits and inspections.

1.07 INTERPRETATION OF DRAWINGS

A. Unless specifically stated to the contrary, the Drawings do not show exact locations of conduit runs. Coordinate the conduit installation with other trades and the actual supplied equipment.

B. Install each 3 phase circuit in a separate conduit unless otherwise shown on the Drawings.

C. Conduit shown exposed shall be installed exposed; conduit shown concealed shall be installed concealed. Unless otherwise indicated install branch circuit conduits exposed in process/industrial type spaces and concealed in finished spaces.

D. Where circuits are shown as "home-runs" all necessary fittings and boxes shall be provided for a complete raceway installation. Where home-runs indicate conduit is to be installed concealed or exposed the entire branch circuit shall be installed in the same manner.

E. Verify the exact locations and mounting heights of lighting fixtures, switches and receptacles prior to installation.
F. Except where dimensions are shown, the locations of equipment, fixtures, outlets and similar devices shown on the Drawings are approximate only. Exact locations shall be determined by the Contractor and approved by the Engineer during construction. Obtain information relevant to the placing of electrical work and in case of any interference with other work, proceed as directed by the Engineer and furnish all labor and materials necessary to complete the work in an approved manner.

G. Circuit layouts are not intended to show the number of fittings, or other installation details. Furnish all labor and materials to install and place in satisfactory operation all power, lighting and other electrical systems shown.

H. Redesign of electrical or mechanical work, which is required due to the Contractor's use of an alternate item, arrangement of equipment and/or layout other than specified herein, shall be done by the Contractor at his/her own expense. Redesign and detailed plans shall be submitted to the Engineer for approval. No additional compensation will be provided for changes in the work, either his/her own or others, caused by such redesign.

I. Raceways and conductors for low voltage (120 Volts) thermostats controlling HVAC unit heaters, exhaust fans and similar equipment are not shown on the Drawings. Provide raceways and conductors between the thermostats, the HVAC equipment and the motor starters for a complete and operating system. Raceways shall be installed concealed in all finished space and may be installed concealed or exposed in process spaces. Refer to the HVAC drawings for the locations of the thermostats.

1.08 SIZE OF EQUIPMENT

A. Investigate each space in the structure through which electrical equipment furnished under Division 16 must pass to reach its final location. Coordinate shipping splits with the manufacturer to permit safe handling and passage through restricted areas in the structure.

B. The equipment shall be kept upright at all times during storage and handling. When equipment must be tilted for passage through restricted areas, brace the equipment to ensure that the tilting does not impair the functional integrity of the equipment.

1.09 RECORD DRAWINGS

A. As the work progresses, legibly record all field changes on a set of Project Contract Drawings, hereinafter called the "Record Drawings."

1.10 MATERIALS AND EQUIPMENT

A. Materials and equipment furnished under this contract shall be new.

B. Material and equipment of the same type shall be the product of one manufacturer and shall be UL listed.

1.11 EQUIPMENT IDENTIFICATION

A. Identify equipment, disconnect switches, separately mounted motor starters, control stations, etc. furnished under Division 16 with the name of the equipment it serves. Motor control
centers, control panels, panelboards, switchboards, switchgear, junction or terminal boxes, transfer switches, etc., shall have nameplate designations as shown on the Drawings.

B. Nameplates shall be engraved, laminated plastic, not less than 1/16-in thick by 3/4-in by 2-1/2-in with 3/16-in high white letters on a black background.

C. Nameplates shall be screw mounted to NEMA 1 enclosures. Nameplates shall be bonded to all other enclosure types using an epoxy or similar permanent waterproof adhesive. Two sided foam adhesive tape is not acceptable. Where the equipment size does not have space for mounting a nameplate the nameplate shall be permanently fastened to the adjacent mounting surface.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 LEEVES AND FORMS FOR OPENINGS

A. Provide and place all sleeves for conduits penetrating floors, walls, partitions, etc. Locate all slots for electrical work and form before concrete is poured.

B. Exact locations are required for stubbing-up and terminating concealed conduit. Obtain shop drawings and templates from equipment vendors or other subcontractors and locate the concealed conduit before the floor slab is poured.

C. Where setting drawings are not available in time to avoid delay in scheduled floor slab pours, the Engineer may allow the installations of such conduit to be exposed. Requests for this deviation must be submitted in writing. No additional compensation for such change will be allowed.

3.02 CUTTING AND PATCHING

A. Cutting and patching shall be done in a thoroughly workmanlike manner and be in compliance with modifications and repair to concrete as specified. Saw cut concrete and masonry prior to breaking out sections.

3.03 INSTALLATION

A. Work not installed according to the Drawings and Specification shall be subject to change as directed by the Engineer at Contractor's expense.

B. Electrical equipment shall be protected against mechanical and water damage. Store all electrical equipment in dry permanent shelters. Do not install electrical equipment in place until structures are weather-tight.

C. Damaged equipment shall be replaced or repaired by the equipment manufacturer, at the Engineer's discretion and at the Contractor's expense.

D. Repaint any damage to factory applied paint finish using touch-up paint furnished by the equipment manufacturer.
3.04 WORK SUPERVISION

A. The Contractor shall designate in writing the qualified electrical supervisor who shall provide supervision to all electrical work on this project. The minimum qualifications for the electrical supervisor shall be a unlimited electrical journeyman as defined by the Oklahoma Construction Industries Board. The supervisor or his appointed alternate possessing at least a journeyman electrician license shall be on site whenever electrical work is being performed. The qualifications of the electrical supervisor shall be subject to approval of the Owner and the Engineer.

END OF SECTION
PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish and install complete raceway systems as shown on the Drawings and as specified herein.

B. Home runs indicated are to assist the contractor in identifying raceways to be installed concealed or exposed. Raceways identified to be installed exposed on the Drawings shall be run near the ceilings or along the walls of the areas through which they pass and shall be routed to avoid conflicts with HVAC ducts, cranes and hoists, lighting fixtures, doors and hatches. Raceways indicated to be run concealed shall be run in the center of concrete floor slabs, in partitions, or above hung ceilings, as required.

PART 2 PRODUCTS

2.01 RACEWAYS AND FITTINGS

A. Aluminum Conduit and Fittings

1. Rigid Aluminum conduit, couplings, factory elbows and fittings shall be 6063 alloy and shall comply with ANSI C80.5.

2. Acceptable manufacturers:
   a. New Jersey Aluminum Corp.
   b. AFC Co.
   c. VAW of America, Inc.
   d. Or Equal.

B. Steel Conduit and Fittings

1. Rigid metal conduit (GRS), couplings, factory elbows and fittings shall be heavy wall steel tubing with a hot-dipped galvanized finish inside and out after threading and shall comply with ANSI C 80.1 and UL/6.

2. Intermediate metal conduit (IMC), couplings, factory elbows and fittings shall be medium wall steel tubing with a hot-dipped galvanized finish inside and out after threading and shall comply with UL/1242.

3. Electrical metallic tubing (EMT), factory elbows and fittings shall be thin wall steel tubing with an electrically galvanized finish after fabrication and comply with ANSI C80.3 and UL/797.
4. Acceptable manufacturers:
   a. Allied Tube & Conduit Corp.
   b. LTV Steel Tubular Products Corp.
   c. Triangular PWC Inc.
   d. Or equal.

5. Rigid metal and intermediate metal conduit fittings shall be of the threaded type, and shall be steel or malleable iron, with a hot-dipped galvanized finish. Threadless fittings and split couplings are not allowed except in specific applications as approved by the Engineer.

6. Electrical metallic tubing fittings shall be of the rain tight, concrete tight, compression type with malleable iron or pressure cast steel body, steel hex type compression nut and electrically galvanized finish.

7. Acceptable manufacturers:
   a. Appleton Electric Co.
   b. O-Z Gedney Co.
   c. RACO Inc.
   d. Gould/Efcor
   e. Steel City
   f. Or equal

C. PVC Coated Rigid Steel Conduit and Fittings

1. PVC coated rigid steel conduit shall be heavy wall steel tubing with a hot-dipped galvanized finish inside and out after threading with a minimum 0.040-in thick, polyvinyl chloride coating permanently bonded to it and an internal chemically cured urethane or enamel coating. The rigid steel conduit shall comply with ANSI C80.1 and UL/6 prior to coating.

2. PVC coated couplings, factory elbows and fitting shall be furnished with a PVC coating bonded to steel the same thickness as used on the PVC coated conduit. The ends of all couplings, fittings, etc. shall have a minimum of one pipe diameter in length of PVC overlap.

3. Acceptable manufacturers:
   a. “OCAL” as manufactured by Thomas & Betts
   b. "Plasti-Bond Red" as manufactured by Robroy Industries
c. Triangle PWC Inc

d. Or equal

D. Non Metallic Conduit and Fittings

1. PVC conduit shall be rigid polyvinyl chloride schedule 40. Rigid PVC conduit up to trade sizes 3-1/2-in shall comply with NEMA TC-2 and UL/651 and shall be sunlight resistant, rated for use with 90 degree C conductors in exposed, direct burial or concrete encased applications. Underground utility duct, 4-in trade size and above, shall be polyvinyl chloride (PVC).

2. Connectors, couplings, fittings and ancillary materials shall be supplied by the conduit manufacturer. Connectors, fittings and ancillary materials shall be rated for the environment for which they are installed.

3. Acceptable manufacturers:
   a. Carlon Corp.
   b. Certained Corp.
   c. Conux Pipe Systems, Inc.
   d. Or equal.

E. Liquid-tight Flexible Metal Conduit, Couplings and Fittings

1. Liquid-tight flexible metal conduit shall be square locked, galvanized steel flexible conduit with a moisture proof, flame resistant, polyvinyl chloride jacket, for use with rigid metal conduit systems. Sealtite, Type UA, manufactured by the Anaconda Metal Hose Div.; Anaconda American Brass Co.; American Flexible Conduit Co., Inc.; Universal Metal Hose Co. or equal.

2. Liquid-tight conduit fittings shall be hot-dipped mechanically galvanized, positive grounding, screw in type. Provide external bonding lugs on sizes 1-1/4-in and larger. Box connectors shall have insulated throats as manufactured by the Thomas & Betts Co.; Crouse-Hinds Co. or equal.

3. Acceptable Manufacturers:
   a. American Flexible Conduit Co.
   b. Anaconda Metal Hose/ANAMET Inc.
   c. Electri-flex Co.
   d. Thomas & Betts
   e. O-Z Gedney
   f. Or equal
2.02 BOXES AND FITTINGS

A. Dry and Damp Location Boxes and Fittings

1. Outlet boxes shall be zinc-galvanized, extra depth, pressed steel with knockouts and of size and type suitable for the intended application.

2. Boxes that are less than 100 cubic inches in size used for junction or pull boxes shall be zinc galvanized pressed steel not less than 14 USS gauge with appropriate blank covers, minimum size 4-11/16-in square by 2-1/8-in deep.

3. Boxes that are 100 cubic inches and larger shall be constructed of hop dip galvanized sheet steel without knockouts. Covers shall be secured with round head brass machine screws. All joints shall be welded and ground smooth.

4. Terminal cabinets shall be NEMA 12 sheet steel unless otherwise shown on the Drawings. Boxes shall be painted and have continuously welded seams. Welds shall be ground smooth and galvanized. Box bodies shall be flanged and shall not have holes or knockouts. Box bodies shall not be less than 14 gauge metal and covers shall not be less than 12 gauge metal. Terminal boxes shall be furnished with latching hinged doors, terminal mounting straps and brackets. Terminal blocks shall be rated not less than 20A, 600V.

5. Acceptable Manufacturers:
   a. Appleton
   b. Raco
   c. Steel City
   d. Hoffman
   e. Electromate Division of Robroy Ind.
   f. Wiegmann

B. Wet Location Boxes and Fittings

1. NEMA 4 terminal boxes, junction boxes, pull boxes, etc, shall be sheet Type 316 stainless steel unless otherwise shown on the Drawings. Boxes shall have continuously welded seams and mounting feet. Welds shall be ground smooth. Boxes shall be flanged and shall not have holes or knockouts. Box bodies shall not be less than 14 gauge metal and covers shall not be less than 12 gauge metal. Covers shall be gasketed and fastened with stainless steel clamps. Terminal boxes shall be furnished with hinged doors, terminal mounting straps and brackets. Terminal blocks shall be NEMA type, not less than 20 Amps, 600 Volt.

2. Cast or malleable iron device boxes shall be Type FD. Boxes and fittings shall have cadmium-zinc finish with cast covers and stainless steel screws.
3. Cast aluminum device boxes shall be Type FD. Boxes and fittings shall be copper free aluminum with cast aluminum covers and stainless steel screws.

4. Acceptable Manufacturers:
   a. Appleton
   b. Crouse-Hinds
   c. Steel City
   d. Hoffman
   e. Electromate - Division of Robroy Ind.
   f. Or equal

C. Hazardous (Classified) Location Boxes
   1. Explosion-proof boxes shall be designed for Class 1, Group D, Division 1 hazardous locations, and shall also have O-ring seals to meet NEMA 4 requirements. Boxes and covers shall be aluminum, with stainless steel hinges and stainless steel bolts; Type EJB-N4 as manufactured by the Crouse-Hinds Co.; Appleton Electric Co.; Adalet-PLM or equal.

2.03 HARDWARE

A. Conduit Mounting Equipment
   1. Stainless steel channel with stainless steel hardware shall be used in ALL indoor areas and in outdoor locations.
   2. Furnish any and all necessary supports, brackets, conduit sleeves, racks and bracing as required. All boxes and hardware shall be stainless steel.

B. Conduit Supports
   1. Trapezes
      a. In dry indoor areas, beams, channels, struts, hangers, bracing, rods, beam clamps, accessories and components shall be stainless steel.
      b. Stainless steel beams, channels, struts or fiberglass beams, channels, struts with stainless steel hangers, bracing, rods, beam clamps, accessories and components shall be used in all areas.
   2. Conduit Racks
      a. In dry indoor areas, conduit racks, accessories and components shall be stainless steel.
b. Stainless steel conduit racks with stainless, accessories and components shall be
    shall be used in all areas.

PART 3 EXECUTION

3.01 RACEWAY APPLICATIONS
    A. Refer to Table 16110-1 for specific raceway application requirements.
    B. All conduit of a given type shall be the product of one manufacturer.

3.02 BOX APPLICATIONS
    A. Terminal boxes, junction boxes and pull boxes shall have NEMA ratings suitable for the
       location in which they are installed.
    B. All conduit bodies and pulling outlets shall comply with NEC wire bending space requirements.
       Mogul type fittings shall be used for sizes 2-1/2-in and larger.
### TABLE 16110-1

**Raceway Application Guidelines**

<table>
<thead>
<tr>
<th>Location/Circuit Type</th>
<th>Raceway Type</th>
</tr>
</thead>
</table>
| **All locations**     | - Exposed – Rigid Aluminum conduit.  
  - Underground - PVC duct (as specified) in concrete duct bank. |
|                       |              |
| **Clean, dry non-finished areas - electrical rooms, generator rooms, mechanical rooms, shops, dry storage, etc.** | - Exposed – Rigid Aluminum conduit. |
| **Process areas - non-corrosive, non-hazardous locations designated as DAMP or WET on the Drawings.** | - Exposed – Rigid Aluminum conduit. |
| **Hazardous areas - all locations - Class 1, Division 1 and 2.** | - Exposed – Rigid Aluminum conduit, where allowed by code, otherwise Galvanised rigid conduit (GRS) |
| **Outdoor areas - all locations.** | - Exposed – Rigid Aluminum conduit. |

#### 3.03 FITTINGS APPLICATIONS

A. Combination expansion-deflection fittings shall be used where exposed conduits cross structure expansion joints or in straight runs where expansion is anticipated. Combination expansion-deflection fittings shall be installed where embedded conduits cross structural expansion joints. Refer to Structural Drawings for expansion joint locations. Provide bonding jumpers around fittings.
B. All underground conduit penetrations at walls or other structures shall be sealed watertight. Conduit wall seals and sleeves shall be used in accordance with the manufacturer’s installation instructions and the details shown on the Drawings.

C. Conduit sealing bushings shall be used to seal conduit ends exposed to the weather and at other locations shown on the Drawings.

D. **Gas Containment Area Sealing**
   1. Internally and externally seal each conduit entering or leaving any area containing noxious gases to prevent contamination into clean areas via the conduit system. Areas requiring this protection are rooms where chlorine, ammonia and ozone are stored, generated or handled. Caulking material for conduit internal use shall be synthetic elastomer type, 3M, Series CP25 or equal. External sealing shall be in accordance with the typical details shown on the Drawings.

E. Insulated throat grounding bushings shall be used where specified herein and where conduits stub up into electrical equipment such as MCC’s, switchgear, etc.

3.04 INSTALLATION

A. No conduit smaller than 3/4-in electrical trade size shall be used, nor shall any have more than the equivalent of three 90 degree bends in any one run. Pull boxes shall be provided as required by the NEC after every 270 degrees of bends and for straight run not to exceed 200 feet or as directed.

B. All conduit which may under any circumstance contain liquids such as water, condensation, liquid chemicals, etc, shall be arranged to drain away from the equipment served. If conduit drainage is not possible, conduit seals shall be used to plug the conduits. The ends of all conduits shall be temporarily plugged to exclude dust, moisture and debris from entering during construction.

C. Conduit ends exposed to the weather shall be sealed with conduit sealing bushings.

D. Conduits noted as spare shall be capped or plugged at both ends with easily removable fittings.

E. Conduit terminating in NEMA 3R, 4, 4X enclosures shall be terminated with Myers type conduit hubs.

F. Conduit terminating in pressed steel boxes shall have double locknuts and insulated bushings.

G. Conduits containing equipment grounding conductors and terminating in sheet steel boxes shall have insulated throat grounding bushings.

H. Conduits shall be installed using threaded fittings except for PVC or EMT.

I. The use of running threads is prohibited. Where such threads are necessary, a 3-piece union shall be used.

J. All conduits entering or leaving a motor control center, switchboard or other multiple compartment enclosure shall be stubbed up into the bottom horizontal wireway or other
manufacturer’s designated area, directly below the vertical section in which the conductors are to be terminated. The 3-in extension of conduit above the floor slab or concrete equipment pad may be reduced to a dimension that suits the equipment manufacturer’s installation requirements if the 3-in stub-up interferes with the equipment being provided.

K. Rigid galvanized steel conduits buried in earth shall be completely painted with bitumastic.

L. Rigid galvanized steel conduits which have been field cut and threaded shall be painted with cold galvanizing compounds.

M. PVC coated rigid galvanized steel conduit shall be used for elbows at risers at the utility pole for electrical and telephone service conduits. Rigid galvanized steel conduit shall be used at utility pole for electrical and telephone service and fire alarm conduits to a height of 10-ft above finished grade. Furnish and install weather heads at service pole riser if required by utility company.

N. Liquid-tight flexible metal conduit shall be used for all motor terminations, the primary and secondary of transformers, generator terminations and other equipment where vibration is present or may require removal. Non-metallic flexible conduit can be used with rigid PVC conduit systems.

O. Flexible couplings shall be used in hazardous locations for all motor terminations and other equipment where vibration is present.

P. PVC coated rigid steel conduit shall be used as a transition section where concrete embedded conduit stubs out of floor slabs or through below grade walls or where conduit installed under building slabs on grade stub out of floors. The PVC coated rigid steel conduit shall extend a minimum of 3-in into and out of the floor slab, concrete pad, or wall to allow for proper threading of the conduit.

Q. Expansion fittings shall be used on exposed runs of PVC conduit where required for thermal expansion. Installation and number of fittings shall be as recommended by manufacturer.

R. Conduit supports, other than for underground raceways, shall be spaced at intervals not exceeding the distance required by the NEC to obtain rigid construction.

S. Single conduits shall be supported by means of one-hole pipe clamps in combination with one-screw back plates, to raise conduits from the surface. Multiple runs of conduits shall be supported on fabricated channel trapeze type racks with steel horizontal members and threaded hanger rods. The rods shall be not less than 3/8-in diameter. Surface mounted panel boxes, junction boxes, conduit, etc, shall be supported by spacers to provide a minimum of 1/2-in clearance between wall and equipment.

T. Conduit Supports (Other than Underground Raceways)

1. Trapezes
   a. Conduit support trapezes shall be vertically supported every 10-ft or less, as required to obtain rigid conduit construction.
   b. Lateral seismic restraints (Sway Bracing) shall be spaced 30-ft or less.
c. Horizontal seismic restraints shall be spaced at 40-ft or less. There shall be at least one horizontal restraint per horizontal run.

d. Attachment to structural steel shall be by beam clamps or welded beam attachment. C-clamps will not be allowed for vertical hangers. Side beam clamps with beam hooks shall be used for seismic restraint only.

e. Attachment to concrete shall be cast-in-place inserts, cast-in place welded plates with welded studs or stainless steel adhesive anchors.

2. Flush Mounted Supports

a. Support shall be spaced 10-ft or less, as required to obtain rigid conduit construction.

b. Attachment to concrete shall be with cast-in-place inserts, cast-in place welded plates with welded studs or stainless adhesive anchors.

3. Conduit Racks

a. Support shall be spaced 10-ft or less, as required to obtain rigid conduit construction.

b. Horizontal seismic restraints shall be spaced at 30-ft or less, with welded studs or stainless adhesive anchors.

4. Conduit Hangers

a. Conduit hangers shall be vertical supported 10-ft or less, as required to obtain rigid conduit construction.

b. Lateral seismic restraints (Sway Bracing) shall be spaced 20-ft or less.

c. Horizontal seismic restraints shall be spaced at 30-ft or less. There shall be at least one horizontal restraint per horizontal run.

d. Attachment to structural steel shall be by beam clamps or welded beam attachment. C-clamps will not be allowed for vertical hangers. Side beam clamps with beam hooks shall be used for seismic restraint only.

e. Attachment to concrete shall be cast-in-place inserts, cast-in place welded plates with welded studs or stainless steel adhesive anchors.

5. All reinforcing bars shall be located by the Electrical Subcontractor with the use of a rebar locator prior to installing adhesive capsule type anchors. Mark the location of all reinforcing bars in an area bounded by a line drawn at least 18-in from the edge of the support bearing/weld plates on all four sides of the bearing/weld plates prior to fabricating and installing bearing/weld plates.

6. Where interference occurs, adjust anchor locations to clear reinforcing bars and alter support configuration at no additional cost to the Authority.
U. Miscellaneous steel for the support of fixtures, boxes, transformers, starters, contactors, panels and conduit shall be furnished and installed. Channel supports shall be ground smooth and fitted with plastic end caps.

V. Steel channels, flat iron and channel iron shall be furnished and installed for the support of all electrical equipment and devices, where required, including all anchors, inserts, bolts, nuts, washers, etc, for a rigid installation. Channel supports shall be ground smooth and fitted with plastic end caps.

W. 3/16-in polypropylene pull lines shall be installed in all new conduits noted as spares or designated for future equipment. Conduit noted as spare shall be capped or plugged at both ends with easily removable fittings.

X. Where no type or size is indicated for junction boxes, pull boxes or terminal cabinets, they shall be sized in accordance with the requirements of NEC Article 314. Enclosure type and material shall be as specified herein.

Y. Pull or junction boxes shall be furnished and installed where shown on the Drawings, in every 200 feet of straight conduit runs or in runs where more than the equivalent of four 90 degree bends occur or at any point necessary for wire pulling and splicing. Splices shall not be made in pulling elbows.

END OF SECTION
PART 1  GENERAL

1.01.  SCOPE OF WORK

   A. Furnish, install and test all wire, cable and appurtenances as shown on the Drawings and as specified herein.

1.02.  DELIVERY, STORAGE AND HANDLING

   A. Carefully handle all conductors to avoid kinks and damage to insulation.

PART 2  PRODUCTS

2.01.  GENERAL

   A. Wires and cables shall be of annealed, 98 percent conductivity, soft drawn copper.

   B. All conductors shall be stranded, except that lighting and receptacle wiring may be solid.

   C. Except for control, signal and instrumentation circuits, wire smaller than No. 12 AWG shall not be used.

   D. Wire shall have 600 Volt insulation except where indicated otherwise.

2.02.  BUILDING WIRE

   A. Wire for lighting, receptacles and other circuits not exceeding 150 Volts to ground shall be NEC type THHN/THWN as manufactured by General Cable.; American Insulated Wire Corp.; Southwire Co.; or equal.

   B. Wire for circuits over 150 Volts to ground within buildings and structures shall be NEC type THHN/THWN as manufactured by General Cable.; American Insulated Wire Corp.; Southwire Co.; or equal.

   C. Wire for circuits over 150 Volts to ground used underground or for service entrance shall be NEC type THHN/THWN as manufactured by General Cable.; American Insulated Wire Corp.; Southwire Co.; or equal.

   D. Bare copper ground wire shall be stranded, annealed copper wire ASTM-B3 alloy coated soft copper electrical wire ASTM B189.

   E. Equipment grounding conductors shall be NEC Type THW green and sized in accordance with NEC Table 250-122. Ground grid conductors shall be insulated unless shown otherwise on the Drawings.

2.03.  CONTROL, STATUS AND ALARM WIRE

   A. Wire shall be No.14 AWG NEC type THHN/THWN stranded as manufactured by The Okonite Co.; General Cable.; American Insulated Wire Corp.; Southwire Co.; or equal.
2.04. INSTRUMENTATION WIRE

A. Wire for process instrumentation signals (i.e. 1-5 VDC, 4-20 mA DC), R.T.D., potentiometer and similar signals shall be:

1. Single pair cable:
   a. Conductors: 2 No. 16 stranded and twisted on 2-in lay
   b. Insulation: XLP with 600 Volt, 105 degrees C rating
   c. Shield: 100% Aluminum/polyester foil with drain wire
   d. Jacket: PVC with UL Subject 13, UL 1581 and manufacturers’ identification
   e. Max overall diameter: 0.262-in
   f. Miscellaneous: UL Listed as Instrument Tray Cable for use in accordance with Article 727 and Article 725 of the NEC.
   g. Manufacturers: Belden; Manhattan; General Cable; The Okanite Co.; or equal

2. Area Network (LAN) Ethernet cable shall be designed for use with a high-speed (100 Mbps/Gbps) Ethernet communications network. The twisted pair cable shall have nominal impedance of 100 ohms at 1 Mhz and a maximum attenuation of 10 dB per 1000 feet at 1 Mhz. The twisted pair cable shall be plenum rated and shall have a minimum of four 24 AWG solid copper conductor pairs. All RJ-45 terminations on the twisted pair cable shall be done as specified by the manufacturer. Terminations shall provide strain relief on the cable jacket. Strain relief on the wire and/or wire insulation shall not be acceptable. Cable and connections shall meet or exceed Category 5 ratings and upon completion of the network installation, the system shall be tested to Category 5 standards. Category 5 cable shall be as manufactured by Belden; Phoenix; Digital; Seicor, or equal.

2.05. SPLICES (POWER CONDUCTORS)

A. Unless otherwise indicated on the Drawings, splices shall not be made in the cables without prior written approval of the Engineer. Where splicing is approved by the Engineer, splicing materials for all 600 Volt splices shall be made with long barrel, tin plated copper compression (hydraulically pressed) connectors and insulated with heavy wall heat shrinkable tubing. The conductivity of all completed connections shall be not less than that of the uncut conductor. The insulation resistance of all completed connections of insulated conductors shall be not less than that of the uncut conductor.

B. Wire lugs shall be tin plated copper, long barrel compression type (hydraulically pressed) for wire sizes No. 8 AWG and larger. Lugs for No. 10 AWG and smaller wire shall be locking spade type with insulated sleeve. Lugs shall be as manufactured by the Thomas and Betts Co.; Burndy; Amp; or equal.

C. Compression type connectors shall be insulated with a heat shrink boot or outer covering and
epoxy filling. Splice kits shall be as manufactured by Raychem (Tyco); Ideal Industries; 3M Co. or equal.

D. Solderless pressure connectors shall be self-contained, waterproof and corrosion-proof units incorporating prefilled silicone grease to block out moisture and air. Connectors shall be sized according to manufacturer's recommendations. The connectors shall be UL listed and CSA approved, as manufactured by King Innovation; Ideal Industries, Inc., or equal.

2.06. MOTOR CONNECTIONS

A. Motor connections shall be ring type mechanical compression terminations installed on the branch circuit wires and the motor leads and secured with bolt, nut and springwasher. Connections shall be insulated with a Raychem Type RVC, roll-on stub insulator; Thomas & Betts, Shrink-Kon MSCV20; or equal. For wire sizes N0. 8 and larger, long barrel, tin plated copper compression (hydraulically pressed) type connections Burndy Co., or equal) shall be installed on the branch circuit wires and the motor leads. Connections shall be insulated with heavy duty heat shrinkable material (Raychem Corp., or equal.

2.07. TERMINATION AND SPLICES (CONTROL, STATUS AND ALARM CONDUCTORS)

A. Termination connectors shall be of the locking fork-end (upturned leg ends) type as manufactured by Ideal Industries; 3M Co.; Panduit Corp. or equal.

B. Insulated compression type connectors shall be of the expanded vinyl insulated parallel or pigtail type as manufactured by Ideal Industries; 3M Co.; Panduit Corp. or equal.

C. Solderless pressure connectors shall be self-contained, waterproof and corrosion-proof units incorporating prefilled silicone grease to block out moisture and air. Connectors shall be sized according to manufacturer's recommendations. The connectors shall be UL listed and CSA approved, as manufactured by King Innovation; Ideal Industries, Inc or equal.

2.08. TERMINATIONS (INSTRUMENTATION CABLES)

A. Termination connectors shall be of the locking fork-end (upturned leg ends) type as manufactured by Ideal Industries; 3M Co.; Panduit Corp. or equal.

2.09. WIRE AND CABLE MARKERS

A. Wire and cable markers shall be "Omni-Grip" as manufactured by the W.H. Brady Co.; Thomas & Betts Co., SMS; 3M Co., STD-TAG; or equal.

B. Wire and cables with diameters exceeding the capacity of the "Omni-Grip" shall be marked with pre-printed, self-adhesive vinyl tapes as manufactured by the W.H. Brady Co.; Panduit Corp.; 3M Co.; or equal.

PART 3 EXECUTION

3.01. INSTALLATION

A. Uniquely identify all wires, cables and each conductor of multi-conductor cables (except lighting and receptacle wiring) at each end and in all manholes, hand holes and pull boxes with
wire and cable markers.

B. Use lubrications to facilitate wire pulling. Lubricants shall be UL approved for use with the insulation specified.

C. Provide multi-conductor control and signal cables within the underground system. Cables shall be installed continuous from building to building without splices. Individual control conductors and twisted shielded pairs signal cables will not be allowed in underground systems.

D. The crimping tools used in securing the conductor in the compression type connectors or terminal lugs shall be those made for that purpose and for the conductor sizes involved. The crimping tool shall be the ratchet type which prevents the tool from opening until the crimp action is completed. Such tools shall be a product of the connector manufacturer.

E. Install an equipment grounding conductor in all raceways.

F. Seal openings in slabs and walls through which wires and cables pass.

G. Pull cables from the direction that requires the least tension. Use a feed-in tube and sheave designed for cable installation. Use sheaves with radii that exceed the cable manufacturer’s recommended minimum bending radius. Use a dynamometer and constant velocity power puller. Velocity should not be less than 15-ft./min. or more than 50-ft./min. Do not exceed the cable manufacturer’s maximum recommended tension.

H. If cable can not be terminated immediately after installation, install heat shrinkable end caps.

I. Fireproof exposed cables in manholes, vaults, pullboxes, switchgear and other areas not protected by conduit where medium voltage cables are present. Use fire-proofing tape and glass tape in accordance with the manufacturer’s instructions. Fire-proofing tape shall be installed with one half-lapped layer of Scotch Brand 77 Electric Arc and Fireproofing Tape (3M Corp., or equal). Tape shall be secured with a two-layer band of Scotch Brand 69 Glass Electrical Tape (3M Corp., or equal) over the last wrap.

3.02. WIRE COLOR CODE

A. All wire shall be color coded or coded using electrical tape in sizes where colored insulation is not available. Where tape is used as the identification system, it shall be applied in all junction boxes, manholes and other accessible intermediate locations as well as at each termination.

B. The following coding shall be used:

<table>
<thead>
<tr>
<th>System</th>
<th>Wire</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>240/120 Volts</td>
<td>Neutral</td>
<td>White</td>
</tr>
<tr>
<td>Single-Phase, 3 Wire</td>
<td>Line 1</td>
<td>Black</td>
</tr>
<tr>
<td></td>
<td>Line 2</td>
<td>Red</td>
</tr>
<tr>
<td>208Y/120, Volts</td>
<td>Neutral</td>
<td>White</td>
</tr>
<tr>
<td>3 Phase, 4 Wire</td>
<td>Phase A</td>
<td>Black</td>
</tr>
<tr>
<td></td>
<td>Phase B</td>
<td>Red</td>
</tr>
<tr>
<td></td>
<td>Phase C</td>
<td>Blue</td>
</tr>
</tbody>
</table>
C. Neutral or ground wires that terminate in a Panelboard and require color tape shall have the color tape extend at least 6-in from the termination point.

3.03. TERMINATIONS AND SPLICES

A. Power conductors: Unless otherwise indicated on the Drawings, no splices may be made in the cables without prior written approval of the Engineer. Where splicing is approved, terminations shall be die type or set screw type pressure connectors as specified. Splices (where allowed) shall be die type compression connector and waterproof with heat shrink boot or epoxy filling for copper conductors # 4 AWG and larger. Splices shall be solderless pressure connectors with insulating covers for copper conductors # 6 AWG and smaller. Aluminum conductors (where specified) shall employ terminations and splices specifically designed for aluminum conductors.

B. Control Conductors: Termination on saddle-type terminals shall be wired directly with a maximum of two conductors. Termination on screw type terminals shall be made with a maximum of two spade connectors. Splices (where allowed) shall be made with insulated compression type connectors.

C. Instrumentation Signal Conductors (including graphic panel, alarm, low and high level signals): terminations same as for control conductors. Splices allowed at instrumentation terminal boxes only.

D. Except where permitted by the Engineer no splices will be allowed in manholes, handholes or other below grade located boxes.

E. Splices shall not be made in push button control stations, control devices (i.e., pressure switches, flow switches, etc), conduit bodies, etc.

3.04. INSTRUMENTATION CABLES

A. Instrumentation cables shall be installed in rigid steel raceways as specified. All circuits shall be installed as twisted pairs or triads. In no case shall a circuit be made up using conductors from different pairs or triads. Triads shall be used wherever three wire circuits are required.

B. Terminal blocks shall be provided at all instrument cable junction and all circuits shall be identified at such junctions.

C. Shielded instrumentation wire, coaxial, data highway, I/O and fiber optic cables shall be run
without splices between instruments, terminal boxes, or panels.

D. Ground shielding on instrumentation wires at one end only as recommended by the instrument manufacturer and isolated at all other locations. Terminal blocks shall be provided for inter-connecting shield drain wires at all junction boxes. Where individual circuit shielding is required, each shield circuit shall be provided with its own block.

E. Install shielded instrumentation wire in conduit and pull boxes that contain only shielded instrumentation wire. Instrumentation cables shall be separated from all other (i.e. power, control, etc.) cables in manholes by enclosing them within rigid steel raceways and boxes.

F. Shielded cable terminations at each end shall be provided with heat shrinkable tubing placed over the exposed shield and conductors. The tubing shall extend 1-in minimum over the jacket end and extend 0.5-in minimum from the jacket end over the exposed conductors.

3.05. FIELD TESTING

A. Test all 600 Volt wire insulation with a megohm meter after installation and prior to termination. Make tests at not less than 1000 Volts DC. Test duration shall be one minute. Submit a written test report of the results to the Engineer. Notify the Engineer in writing 48 hours prior to testing.

B. Field testing and commissioning shall be done in accordance with the latest revision of the “Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems” published by the International Electrical Testing Association (NETA Standard ATS-1999) unless otherwise modified by this Section. Minimum wire insulation resistance shall not be less than 250 Megohms.

END OF SECTION
PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish and install all miscellaneous equipment as shown on the Drawings and as specified herein.

1.02 EQUIPMENT LIST

A. This Section provides the requirements for miscellaneous equipment typically employed in a facility, however, not all components specified in this Section are necessarily utilized on this project.

PART 2 PRODUCTS

2.01. MATERIALS

A. Disconnect Switches

1. Disconnect switches shall be heavy-duty, quick-make, quick-break, visible blades, 600 Volt, 3 Pole with full cover interlock, interlock defeat and flange mounted operating handle. All current carrying parts shall be copper.

2. NEMA 4 enclosures shall be stainless steel.

3. NEMA 4X enclosures shall be stainless steel.

4. Switches shall be as manufactured by the Square D Co.; General Electric; Cutler-Hammer, or equal.

B. General Purpose Dry Type Transformers

1. Transformers shall be dry type, two-winding with kVA and voltage ratings as shown on the Drawings. Transformer shall incorporate a 220 degree C insulation system and be designed not to exceed 150 degrees C temperature rise above a 40 degree C ambient full load.

2. Four full capacity taps shall be furnished, two 2-1/2 percent above and two 2-1/2 percent below rated primary voltage.

3. Windings shall be copper.

4. Transformers shall be built in accordance with ANSI C89.2 and NEMA ST-20 shall be UL listed and suitable for non-sinusoidal current loads with a K-factor of 4.

5. Transformers, other than K-rated units, shall meet the efficiency levels contained in Tables 4.1 and 4.2 of NEMA Standard TP1-1996 and shall contain an EPA “Energy Star” label. Efficiency shall be tested in accordance with TP1-1996.
6. Transformers shall have common core construction with low hysteresis and eddy current losses. The core flux density shall be below the saturation point to prevent overheating caused by harmonic distortion.

7. Transformer impedance shall be a minimum of 3 percent and a maximum of 5 percent.

8. Provide vibration isolators for transformers rated 112.5 kVA and higher.

9. Provide ground lug on frame and strap ground core assembly to frame of enclosure.

10. The neutral bus shall be sized and configured for 200 percent of secondary full load current.

11. Transformers shall be manufactured by Square D Co.; General Electric Co.; Cutler-Hammer, or equal.

C. Intrinsically Safe Relays

1. Intrinsically safe relays shall be solid state type with 5 Amp output contacts, suitable for use on a 120 Volt, 60 Hz power supply and shall be FM approved for pilot devices in Class I, Division 1, Group D hazardous atmospheres.

2. Intrinsically safe relays shall be Gems Solid State Safe-Pak as manufactured by Gems Sensors, Division of Transamerica Delaval, Inc.; R. Stahl, Inc; MTL Inc., or equal.

D. Equipment Identification Nameplates

1. All field mounted electrical equipment such as disconnects, push button stations, etc, shall be provided with a weather resistant engraved laminoid equipment identification nameplate screwed or bolted adjacent to the device. Nameplate shall identify the mechanical equipment controlled exactly as shown on the electrical singleline drawings (i.e, P-95 Cooling Water Pump No. 1).

E. Arc Flash Protection Warning Signs

1. Provide field-affixed arc flash warning labels on all switchboards, panelboards, industrial control panels, and motor control centers in accordance with National Electrical Code Article 110.16.

2. As a minimum, warning signs shall state “WARNING: Arc Flash and Shock Hazard, Appropriate PPE required”, and shall be designed in accordance with ANSI Z535.4-1998. Where available from the equipment manufacturer, additional information including Flash Hazard boundary, incident energy, voltage shock hazard, PPE required, etc. shall be provided.

PART 3 EXECUTION

3.01. INSTALLATION

A. A. Mounting Stands
1. Field mounted disconnects, pushbutton control stations, alarm panels, enclosed starters and circuit breakers, transformers, automatic transfer switches, wireways, contactors, terminal boxes, junction and pull boxes shall be mounted on galvanized or stainless steel stands as specified. Where clearance requirements for stands may not be maintained, the Engineer may direct electric control equipment to be wall-mounted adjacent to the driven equipment, but in no case shall the distance from the drive motor to the control station exceed 3-ft, all at no additional cost to the Owner.

2. Channel supports shall be ground smooth and fitted with plastic end caps.

B. All panelboards located in pedestal cabinets or outdoors and panelboards that have branch circuits feeding exterior to the building shall be equipped with lightning arresters and surge capacitors.

3.02. FIELD TESTING

A. Before supplying power to the alarm panels, the following tests shall be done: Verify that all wiring connection interfaces that are required are present. Check for secure connections. Using a continuity device, verify that all discrete inputs and output to and from the control panel are wired in correct polarity and are operating in the correct state of operation (normally open or closed state). Check for any direct short circuits across all voltage supply sources. As each of the above tests are performed, the Electrical Contractor shall highlight and initial each circuit that is tested. This set of prints shall be signed and left inside the enclosure.

B. Check mechanical interlocks for intended operation. Make any adjustments required.

C. In the event of an equipment fault in the panel, notify the Engineer immediately. After the cause of the fault has been identified and corrected, a joint inspection of the equipment shall be conducted by the Contractor and Engineer. Repair or replace the equipment as directed by the Engineer prior to placing the equipment back into service at no additional cost to the Owner.

END OF SECTION
PART 1 - GENERAL

1.1 SUMMARY

A. Section includes both field-mounted SPDs and integrated SPDs for low-voltage (120 to 600 V) power distribution and control equipment.

1.2 DEFINITIONS

A. \( I_{\text{inj}} \): Nominal discharge current rating.
B. MCOV: Maximum continuous operating voltage.
C. Protection Modes: The pair of electrical connections where the VPR applies.
D. MOV: Metal-oxide varistor; an electronic component with a significant non-ohmic current-voltage characteristic.
E. OCPD: Overcurrent protective device.
F. SCCR: Short-circuit current rating.
G. SPD: Surge protective device.
H. VPR: Voltage protection rating.

1.3 SUBMITTALS

A. Product Data:
   1. For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
   2. Provide verification the SPD is listed or recognized through Underwriters Laboratories to the latest Safety Standard, ANSI/UL 1449 3rd Edition.
   3. Operations and Maintenance Data: SPDs to include operation, and maintenance manuals.

1.4 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to replace or repair SPDs that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: Ten years.

PART 2 - PRODUCTS

2.1 GENERAL SPD REQUIREMENTS

A. SPD with Accessories: Listed and labeled as defined in NFPA 70, by Underwriters Laboratories, and marked for intended location and application.

C. Comply with Underwriters Laboratories ANSI/UL 1283 5th Edition – Electromagnetic Interference Filters. (Applies to Type 2 SPDs)


E. SPDs manufacturer shall be ISO-9001 certified.

F. MCOV of the SPD shall not be less than 115% for 480Y/277V and 125% for 208Y/120V nominal RMS system voltages.

G. SPDs shall be installed internal to the distribution equipment and shall be of the same manufacturer as the equipment. The equipment shall be fully tested and certified to the following UL standards:

- UL 67 = Panelboards
- UL 845 = Motor Control Centers
- UL 857 = Busway
- UL 891 = Switchboards
- UL 1558 = Low Voltage Switchgear

2.2 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide SquareD Surgelogic branded Surge Protection, or comparable product by one of the following:

1. Square D by Schneider Electric
2. Cutler-Hammer
3. Siemens
4. GE

2.3 SERVICE ENTRANCE SUPPRESSOR

A. SPDs: Comply with UL 1449 3rd Edition.

1. SPD Type – All SPDs installed on the line side of the service entrance OCPD shall be Type 1 SPDs. SPDs installed on the load side of the service entrance OCPD shall be either Type 1 or Type 2 SPDs.

2. Type 2 SPDs shall also comply with ANSI/UL 1283.

B. SPDs shall be provided with the following features and accessories:

1. Integral disconnect switch.
2. Internal fusing design capable of disconnecting the SPD before any damaging external effects to the suppressor or surroundings occur.
3. Indicator light(s) display for power and protection status.
5. Form-C contacts- One normally open and one normally closed for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.


C. Surge Current Rating: The surge current rating of the SPD shall be dependent of its Category/Location:

<table>
<thead>
<tr>
<th>Category/Location</th>
<th>Application</th>
<th>Per Phase</th>
<th>Per Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>Service Entrance</td>
<td>240 kA</td>
<td>120 kA</td>
</tr>
<tr>
<td>B</td>
<td>Distribution</td>
<td>160 kA</td>
<td>80 kA</td>
</tr>
</tbody>
</table>

Protection modes: UL 1449 VPR for grounded WYE configured circuits shall not exceed the following:

<table>
<thead>
<tr>
<th>Modes</th>
<th>208Y/120</th>
<th>480Y/277</th>
<th>600Y/347</th>
</tr>
</thead>
<tbody>
<tr>
<td>L-N; L-G; N-G</td>
<td>800 V</td>
<td>1200 V</td>
<td>1500 V</td>
</tr>
<tr>
<td>L-L</td>
<td>1200 V</td>
<td>2000 V</td>
<td>2500 V</td>
</tr>
</tbody>
</table>

Protection modes: UL 1449 VPR for Delta configured circuits shall not exceed the following:

<table>
<thead>
<tr>
<th>Modes</th>
<th>240D</th>
<th>480D</th>
<th>600D</th>
</tr>
</thead>
<tbody>
<tr>
<td>L-G; N-G</td>
<td>1200 V</td>
<td>2000 V</td>
<td>2500 V</td>
</tr>
</tbody>
</table>

D. SCCR: Per NEC 285.6, the short circuit current rating of the SPD shall be equal to or greater than the available short circuit current at the point on the system where installed.

E. Nominal Discharge Current Rating: 20 kA $I_{(n)}$

Note: Surge Protective Devices must carry a minimum Nominal Discharge Current Rating of 20kA to meet the requirements for UL96A – Installation Requirements for Lightning Protection Systems.

2.4 PANELBOARD SUPPRESSORS

A. SPDs: Comply with UL 1449 3rd Edition.

1. Type 1 or Type 2 SPD

2. Type 2 SPDs shall also comply with UL 1283.

B. SPDs shall be provided with the following features and accessories:

1. Indicator light(s) for power and protection status.
2. Internal fusing design capable of disconnecting the SPD before any damaging external effects to the suppressor or surroundings occur.

3. Audible Alarm with silencing switch.

4. Form-C contacts - One normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.

5. Surge counter with reset switch.

C. Surge Current Rating: The surge current rating of the SPD shall be dependent of its Category/Location:

<table>
<thead>
<tr>
<th>Category/Location</th>
<th>Application</th>
<th>Per Phase</th>
<th>Per Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>Distribution</td>
<td>160 kA</td>
<td>80 kA</td>
</tr>
<tr>
<td>B</td>
<td>Branch</td>
<td>120 kA</td>
<td>60 kA</td>
</tr>
</tbody>
</table>

Protection modes: UL 1449 VPR for grounded WYE configured circuits shall not exceed the following:

<table>
<thead>
<tr>
<th>Modes</th>
<th>208Y/120</th>
<th>480Y/277</th>
<th>600Y/347</th>
</tr>
</thead>
<tbody>
<tr>
<td>L-N; L-G; N-G</td>
<td>800 V</td>
<td>1200 V</td>
<td>1500 V</td>
</tr>
<tr>
<td>L-L</td>
<td>1200 V</td>
<td>2000 V</td>
<td>2500 V</td>
</tr>
</tbody>
</table>

Protection modes: UL 1449 VPR for Delta configured circuits shall not exceed the following:

<table>
<thead>
<tr>
<th>Modes</th>
<th>240D</th>
<th>480D</th>
<th>600D</th>
</tr>
</thead>
<tbody>
<tr>
<td>L-G; N-G</td>
<td>1200 V</td>
<td>2000 V</td>
<td>2500 V</td>
</tr>
</tbody>
</table>

D. SCCR: Per NEC 285.6, the short circuit current rating of the SPD shall be equal to or greater than the available short circuit current at the point on the system where installed.

E. Nominal Discharge Current Rating: Minimum of 10 kA I_{(n)}

PART 3 - EXECUTION

3.1 INSTALLATION

A. SPD devices at distribution panels or switchboards shall be mounted integral to the equipment with leads as short as possible (not to exceed 24-in) and the lead size shall be a minimum of 6 AWG or larger. The SPD shall include an integral disconnect switch which has been tested to the surge current rating of the SPD and shall match or exceed the fault current rating of the board. The disconnect switch shall switch the phases and neutral.
B. SPD devices at branch panels shall be direct bus-to-bus connected with leads as short as possible (not to exceed 24-in) and lead size shall be a minimum of 6 AWG or larger.

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections.
   1. Compare equipment nameplate data for compliance with Drawings and Specifications.
   2. Inspect anchorage, alignment, grounding, and clearances.
   3. Verify that electrical wiring installation complies with manufacturer's written installation requirements.

B. An SPD will be considered defective if it does not pass inspections.

C. Prepare inspection reports.

3.3 STARTUP SERVICE

A. Complete startup checks according to manufacturer's written instructions.

B. Do not perform insulation-resistance tests of the distribution wiring equipment with SPDs installed. Disconnect all wires, including neutral of the SPD before conducting insulation-resistance tests, and reconnect them immediately after the testing is over.

C. Energize SPDs after power system has been energized, stabilized, and tested.

END OF SECTION
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 P1or 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.

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 OF WORK

A. Furnish and install a complete underground system of raceways, manholes and handholes as shown on the Drawings and as specified herein.

B. All underground systems shall be encased as shown on the drawings.

C. The Contractor shall be responsible for setting manholes and handholes at the proper elevation such that the pitch of raceways will be towards manholes and handholes and away from structures, vaults and buildings.

D. Where referred in this Section, raceways are underground conduits – Ductbanks are a collection of underground raceways. Underground system is the collection of underground raceways, manholes and handholes.

E. Ductbanks shall be constructed as shown on the drawings up to the building, structure, vault, manhole and handhole.

   1. Ductbank, manhole and handhole depths vary. Coordinate with other utilities, yard piping, yard structures and field conditions to determine required depths and install raceways, manholes and handholes at that required depth at no additional cost to the Owner.

   2. Ductbank routing and manhole/handhole locations shown on the Drawings are diagrammatically depicted. Coordinate with other utilities, yard piping, yard structures and field conditions to determine required paths and depths at no additional cost to the Owner.

PART 2 PRODUCTS

2.01. MATERIALS

A. Raceways shall be polyvinyl chloride conduit.

B. Cable racks, supports, pulling-in irons, manhole steps and hardware shall be galvanized steel as manufactured by Line Materials Co.; Underground Devices, Inc.; Chance or equal.

C. Detectable Warning Tape

   1. Each duckbank section shall be marked by means of a detectable warning tape (tracer tape) as shown on the Drawings. The detectable warning tape shall be capable of being detected or located by either conductive or inductive location techniques.

   2. The detectable warning tape shall consist of 5 mil (.005-in) overall thickness; five-ply composition; ultra-high molecular weight; virgin polyethylene; acid; alkaline and corrosion resistant; with 150 pounds of tensile break strength minimum per 6-in width.
3. The top side of the tracer tape shall be color banded red for electrical and high voltage lines, and orange for signal, communication, telephone and fire alarm lines. Tracer tape shall be 4-in wide with four color bands. The tape shall be inscribed with the warning message for the utility such as “CAUTION – ELECTRICAL LINED BURIED BELOW”. Tape shall be as manufactured by Mutual Industries, Inc.; Terra Tape, Div. of Reef Industries Inc. or equal.

PART 3 EXECUTION

3.01. INSTALLATION

A. Install raceways to drain away from buildings. Raceways between manholes or handholes shall drain toward the manholes or handholes. Raceway slopes shall not be less than 3-in per 100-ft.

B. Use plastic spacers located not more than 4-ft apart to hold raceways in place. Spacers shall provide not less than 2-in clearance between raceways and edge of envelope.

C. The minimum cover for raceway banks shall be 24-in unless otherwise permitted by the Engineer.

D. Raceway terminations at manholes shall be with end bells for PVC conduit and insulated throat grounding bushings for steel conduit.

E. Where bends in raceways are required, use long radius elbows, sweeps and offsets.

F. Swab all raceways clean before installing cable.

G. Plug and seal spare raceways watertight at all manholes, buildings and structures.

H. Seal the ends of raceways and make watertight at all manholes, buildings and structures.

I. Install pulling-in irons opposite all raceway entrances to manholes.

J. Train cables in manholes and handholes and support and restrain them on racks and hooks. Furnish inserts on all manhole and handhole walls for mounting future racks as well as racks required for present installation.

K. PVC Coated Rigid galvanized steel conduit shall be used for elbows and risers at the utility pole for electrical and telephone service conduits.

L. PVC coated rigid galvanized steel elbows shall be used for pad-mounted transformer stub-ups and all stub-ups through concrete floors, walls and slabs.

M. A pull line shall be installed and left in all spare raceways.

N. Install detectable warning tape in all ductbanks as shown on the Drawings. Where trench exceeds 24-in width, provide additional detectable tape runs to mark each side of the ductbank in addition to the one in the center.

3.02. CLEANING
A. All new manholes and handholes shall be thoroughly cleaned of all silt, debris and foreign matter prior to final inspection.

END OF SECTION
PART 1 GENERAL

1.01. SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required and install a complete grounding system in strict accordance with Article 250 of the National Electrical Code NEC.

B. All raceways, conduits, ducts and multi-conductor cables shall contain equipment grounding conductors sized in accordance with the NEC. Minimum sizes shall be No. 12 AWG.

1.02. A supplemental grounding conductor shall be provided from each switchgear, switchboard, motor control center, power panelboard, lighting panelboard, to the buried ground grid. Supplemental grounding conductors shall be installed in PVC Schedule 80 conduit.

PART 2 PRODUCTS

2.01. MATERIALS

A. Conduit shall be as specified under Section 16110.

B. Wire shall be as specified under Section 16120.

C. Ground rods shall be 3/4-in by 10-ft copper clad steel and constructed in accordance with UL 467. The minimum copper thickness shall be 0.25 mm. Ground rods shall be Copperweld; Blackburn; Erico, Inc. or equal.

D. Grounding conduit hubs shall be malleable iron type, and of the correct size for the conduit, as manufactured by Thomas & Betts Co.; Catalog No. 3940 Series, similar by Burndy; O.Z. Gedney Co. or equal.

E. Water pipe ground clamps shall be cast bronze saddle type, and of the correct size for the pipe, as manufactured by Thomas & Betts Co. Cat. No. 2 (1/2-in, 3/4-in, or 1-in size), similar by Burndy; O.Z. Gedney Co. or equal and of the correct size for the pipe.

F. Buried grounding connections shall be by Cadweld process, or equal exothermic welding system.

1. Molds, cartridge materials and accessories shall be provided in kit form and selected per the manufacturer’s written instructions for specific types, sizes and combinations of conductors and connected items. Molds and powder shall be furnished by the same manufacturer.

PART 3 EXECUTION

3.01. INSTALLATION
A. Run grounding electrode conductors in rigid steel conduits. Bond the protecting conduits to the grounding electrode conductors at both ends. Do not allow water pipe connections to be painted. If the connections are painted, dis-assemble them and re-make them with new fittings.

B. Install equipment grounding conductors with all feeders and branch circuits.

C. Bond all steel building columns in new structures together with ground wire in rigid conduit and connect to the distribution equipment ground bus, as shown on the Drawings.

D. Ground wire connections to structural steel columns shall be made with exothermic welds.

E. Metal conduits stubbed into a motor control center or floor mounted electrical enclosure shall be terminated with insulated grounding bushings and connected to the motor control center or electrical enclosure ground bus. Bond boxes mounted below motor control centers to the motor control center ground bus. Size the grounding wire in accordance with NEC Table 250-122, except that a minimum No. 12 AWG shall be used.

F. Liquid tight flexible metal conduit in sizes 1-1/2-in and larger shall have bonding jumpers. Bonding jumpers shall be external, run parallel (not spiraled) and fastened with plastic tie wraps.

G. Ground transformer neutrals to the nearest available grounding electrode with a conductor sized in accordance with NEC Article 250-66.

H. Drive grounding electrodes as shown on the Drawings.

I. All equipment enclosures, motor and transformer frames, conduits systems, cable armor, exposed structural steel and all other equipment and materials required by the NEC to be grounded, shall be grounded and bonded in accordance with the NEC.

J. Seal exposed connections between different metals with No-Oxide Paint Grade A or equal.

K. Ground metal poles supporting outdoor lighting fixtures to a supplemental grounding electrode (rod) in addition to the separate equipment grounding conductor run with the supply branch circuit.

L. Install driven ground rods in manholes and handholes close to wall and set rod depth so 4-in will extend above finished floor. Protect ground rods with double wrapping of pressure-sensitive tape or heat shrunk insulating sleeve from 2-in above to 6-in below concrete floor. Seal floor opening with waterproof, non-shrink grout. Where ground rods are installed outside of manhole or handhole, provide a No. 4/0 AWG bare, tinned copper conductor from ground rod into manhole or handhole through a waterproof sleeve in the wall.

3.02. INSPECTION AND TESTING

A. Inspect the grounding and bonding system conductors and connections for tightness and proper installation.

B. Use Biddle Direct Reading Earth Resistance Tester or equivalent test instrument to measure resistance to ground of the system. Perform testing in accordance with test instrument manufacturer's recommendations using the fall-of-potential method.
C. Resistance to ground testing shall be performed during dry season. Submit test results in the form of a graph showing the number of points measured (12 minimum) and the numerical resistance to ground.

D. Testing shall be performed before energizing the distribution system.

E. Test all grounded cases and metal parts associated with the electrical equipment for continuity with the ground system.

F. Notify the Engineer immediately if the resistance to ground for any building or system is greater than five ohms.

END OF SECTION
PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish and install the outdoor, liquid filled, pad mounted transformer(s) as shown on the Drawings and as specified herein.

1.02 RELATED WORK

1.03 SUBMITTALS

A. Submit shop drawings and product data, for the following:

1. Equipment sectional and plan views, bottom plan showing conduit openings and anchor bolt pattern, bushing arrangement, dimensions, weight and construction details.

2. Winding and core arrangement, materials, ratings and insulation details.

3. Transformer diagrammatic nameplate information.

4. Itemized bill of materials for accessories.

5. Certified shop test reports.

6. Field test reports.

7. Installation and maintenance manuals.

1.04 REFERENCE STANDARDS

A. Transformer(s) shall be designed, built and tested in accordance with the following standards:

1. ANSI C57.12.00 - Standard General Requirements for Liquid-Immersed Distribution, Power and Regulating Transformers.

2. Western Underground Committee Guide 2.13 for vandal resistance.

3. NEMA Standard TRI - Transformers, Regulators and Reactors.


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

1.05 QUALITY ASSURANCE

A. The equipment furnished under this Section shall be the product of a manufacturer who has produced this same type of equipment for a period of at least 10 consecutive years.

B. Transformer(s) shall be designed, assembled and tested by the manufacturer of the core and coil assemblies used in the transformer.
1.06 SYSTEM DESCRIPTION

1.07 DELIVERY, STORAGE AND HANDLING

1.08 PROJECT/SITE REQUIREMENTS

1.09 MAINTENANCE

1.10 WARRANTY

1.11 MANUFACTURERS

A. Acceptable Manufacturers:
   1. ABB - ASEA Brown Boveri
   2. Cooper Power Systems (RTE)
   3. Square D
   4. General Electric

PART 2 PRODUCTS

2.01 RATINGS

A. Transformer self cooled kVA rating(s) shall be as shown on the drawings. Winding temperature rise shall not exceed 65 degrees C above a 30 degree C average ambient temperature, with a maximum ambient not to exceed 40 degrees C, operating at full rated kVA load.

B. Primary windings shall have the following ratings:
   1. Voltage: 15 kV nominal (field verify primary voltage), 3 Phase, 60 Hz
   2. Connection: Delta

C. Secondary windings shall have the following ratings:
   1. Voltage: 480Y/277 Volts
   2. Connection: Grounded wye
   3. Basic Impulse Level (BIL): 30 kV

D. Transformer impedance shall range between 2.6 and 5.4 percent for 500 kVA units and smaller. Impedance of 750 kVA units and above shall be 5.75 percent, subject to ANSI tolerance of plus/minus 7.5 percent.

2.02 CONSTRUCTION
A. Transformer(s) shall be compartmental type, liquid filled, self-cooled, tamper resistant, weatherproof and suitable for mounting on a concrete pad.

B. Transformer tank(s) shall utilize welded steel construction, sealed to withstand an internal pressure of up to 7 psi without distortion, and top oil temperatures ranging from 50 to 105 degrees C. Tank cover shall be designed to permit access to internal components for inspection or repair. Heavy duty, non-removable lifting lugs and jacking pads shall be provided. When required, welded cooling panels or radiators shall be provided on the back and sides of the tank.

C. The high and low voltage compartments shall be located side-by-side separated by a steel barrier. When facing the transformer, the low voltage compartment shall be on the right. Terminal compartments shall be full height, air filled with individual doors. The high voltage door fastenings shall not be accessible until the low voltage door has been opened. The low voltage door shall have a 3-point latching mechanism with vault type handle having provisions for a single padlock. The doors shall be equipped with lift-off type stainless steel hinges and door stops to hold the doors open when working in the compartments. The front sill of the compartment shall be removable to allow the transformer to be rolled or skidded into position over conduit stubs. ANSI tank grounding provisions shall be furnished in each compartment.

D. The core shall be five-legged. Windings and internal leads shall be aluminum, insulated and braced to prevent phase flashovers during fault conditions. Transformers with wye connected primary and secondary windings shall have the primary neutral insulated from the secondary neutral and brought out into the primary compartment through a separate bushing. Both neutral bushings shall be externally connected to the tank with removable copper straps.

E. Transformer insulating oil shall be Exxon Univolt 33 Hydrofined (R) oil, or equal. Insulating oil shall be free of P.C.B. contamination or any E.P.A. listed toxic chemical. The transformer manufacturer shall test the insulating oil for P.C.B. after filling the tank.

F. Furnish a no load, externally operated, lockable, five-position primary winding tap changer located in the secondary terminal compartment. Tap setting must be clearly visible with the compartment door in the open position. Tap adjustments shall be as follows:

1. For 480Y/277 Volt secondary: (2) - 2.5 percent taps above and below rated primary voltage.

G. Terminations

1. High voltage primary terminations shall be arranged for dead front loop feed and conform to ANSI C57.12.26 requirements. Provide one piece integrated bushings for use with elbow terminators and parking stands for disengaged elbows. Bushings shall be externally clamped to allow external replacement. The transformer manufacturer shall furnish 200 Amp load-break elbows (8.3 kV line-to-ground maximum) elbow terminators for each bushing in accordance with ANSI C119.2.

2. Tie connections between primary loop feed bushings shall be rated for 200 Amps.

3. Low voltage secondary bushings shall be externally clamped, molded epoxy, spade type with NEMA standard four or six hole arrangement. Neutral shall be brought out through an insulated bushing and grounded to the tank wall with a removable grounding strap.

2.03 HIGH VOLTAGE PRIMARY SWITCHING AND PROTECTIVE EQUIPMENT
A. Furnish an oil immersed, three phase, gang operated, four position loop feed, load break primary switch, mounted inside the transformer tank. An external, hook stick type switch operator and index plate shall be mounted in the high voltage primary terminal compartment. Switch positions shall be clearly marked. Minimum switch ratings shall be as follows:

1. 15 kV, 200 Amps continuous.
2. Momentary and fault close: 10,000 Amps symmetrical.
3. One minute 60 Hz withstand: 50 kV

B. Furnish three, 1 Pole, 200 Amp, fused air break switches. Fuses shall be current limiting with an interrupting capacity of 50,000 Amps RMS symmetrical. Phase to phase and phase to ground insulating barriers shall be furnished.

C. Primary Fuse Arrangement

1. Provide oil immersed partial range current limiting fuses in series with externally removable Bay-O-Net type expulsion fuses. Fuse mounts shall be dead front, externally removable, hot stick operated, load-break, individual fused disconnect devices, located in the high voltage compartment above the primary bushings to permit fuse replacement without opening the tank. Current limiting fuses shall be accessible through a handhole in the tank cover.

2. The CLF and expulsion fuses shall be properly coordinated such that the CLF protects for fault values above the expulsion fuse interrupting rating, the expulsion fuse protects the CLF for current values below the CLF interrupting capability and the CLF will not operate for low side faults beyond secondary terminals.

D. Lightning Arresters

1. Furnish three 15 kV distribution class lightning arresters mounted in the high voltage primary compartment for surge protection.

2.04 ACCESSORIES

A. Each transformer shall be furnished with the following accessories:

1. Nameplate in the low voltage compartment.
2. 1-in drain plug (75 to 500 kVA) or 1-in drain valve with sampling device (750 to 5000 kVA).
3. 1-in upper filter press and filling plug.
4. 1-in drain valve with sampling device (75 to 500 kVA).
5. Dial type thermometer with maximum temperature indicator, mounted in a sealed drywell in the low voltage compartment.
6. Pressure-vacuum gauge mounted in the low voltage compartment.
8. Pressure relief valve.

9. Pressure relief diaphragm.

10. Sudden pressure relay.

11. Magnetic liquid level gauge located in the low voltage compartment at the 25 degree C level mark.

13. Mounting provision for voltage and current metering transformers.

2.05 SURFACE PREPARATION AND SHOP COATINGS

A. All welds shall be ground smooth and all metal surfaces cleaned of oil, grease and weld spatter using a hot phosphate chemical treatment. A zinc-rich, heat cured epoxy primer shall be applied to inhibit rust.

B. The equipment shall receive an intermediate coat of heat cured epoxy finish color, followed by an air dried finish coat of Outdoor green, Munsell No. 7GY3.29/1.5. After finish painting, all bottom surfaces, and sides up to a minimum of 1-in above the ground shall be protected against corrosion by an epoxy tar coating.

2.06 SHOP TESTING

A. Perform manufacturers standard production testing and inspection in accordance with ANSI Test Code C57.12.90 and/or NEMA TR1. Testing shall include the following as a minimum:

1. Resistance measurements of all windings on the rated voltage connection of each unit and at the tap extremes of one unit only of a given rating on this project.

2. Ratio tests on the rated voltage connection and on all tap connections.

3. Polarity and phase-relation tests on the rated voltage connections.

4. No-load loss at rated voltage on the rated voltage connection.

5. Exciting current at rated voltage on the rated voltage connection.

6. Impedance and load loss at rated current on the rated voltage connection of each unit and on the tap extremes of one unit only of a given rating on this project.

7. Temperature Test or tests shall be made on one unit only of a project covering one or more units of given rating. Tests shall not be required when there is available a record of a temperature test on an essentially duplicate unit.


9. Induced potential tests.

10. Toxic chemical (e.g. P.C.B.) test.

11. Short circuit capability of transformer design.
B. Manufacturer shall certify compliance with transformer coating performance per ANSI C57.12.28.

C. Results of the above tests including no load loss data shall be submitted with final drawings in the form of certified test reports.

PART 3 EXECUTION

3.01 PREPARATION

3.02 INSTALLATION

A. The equipment shall be leveled and anchored directly to a concrete equipment pad as shown on the Drawings. Provide hardware and metal shims for installation. Anchor bolts shall be 1/2-in galvanized steel.

B. Install the equipment in accordance with the manufacturer's instructions.

C. Remove temporary packing and shipping braces. Touch-up damaged paint finishes.

3.03 FIELD TESTING

A. Engage the services of an independent testing firm to inspect and test the installed equipment prior to energization. The testing firm shall provide all material, labor, equipment and technical supervision to perform the tests and inspection. Notify the Owner/Engineer at least 2 weeks prior to scheduling any testing.

B. Equipment testing and inspection shall be performed in accordance with NETA Standard ATS and shall include the following:

1. Visual and mechanical inspection.

2. Ground resistance test.

3. Insulation resistance tests, winding-to-winding and winding-to-ground, using a megohmmeter, at nominal tap position with all cables disconnected.

C. In the event of an equipment fault, notify the Owner/Engineer immediately. After the cause of the fault has been identified and corrected, a joint inspection of the equipment shall be conducted by the Contractor, the Owner/Engineer and the equipment manufacturer’s factory service technician. Repair or replace the equipment as directed by the Owner/Engineer prior to placing the equipment back into service.

3.04 ADJUSTMENT

3.05 CLEANING

A. Remove all rubbish and debris from inside and around the equipment. 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 SUMMARY

A. Scope: Provide labor, material, equipment, related services, and supervision required, including, but not limited to, manufacturing, fabrication, erection, and installation for adjustable or variable frequency motor controllers (also identified as VFDs, AFDs, Variable Frequency Drives, or Adjustable Frequency Drives) as required for the complete performance of the work, and as shown on the Drawings and as herein specified.

B. Section Includes: The work specified in this Section includes, but shall not be limited to, manufacturer assembled separately enclosed VFD systems, rated 600 V and less for the speed control of three-phase squirrel-cage induction motors, and synchronous motors as specified herein and where shown on the associated schedules and the Drawings. Contained within this specification are requirements for manufacturer pre-assembled VFDs contained within these enclosed VFD systems that may be referenced within other specifications.

C. Related Sections: Related sections include, but shall not be limited to, the following:
   1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
   2. Refer to the specifications sections for the VFD driven equipment for additional requirements. The system supplier of the motor driven equipment shall be responsible for furnishing the Variable Frequency Drive where specified or shown.

D. The VFD manufacturer shall verify that the motor to be used is suitable for use with the VFD. Size VFD at 115% of motor FLA.

1.2 REFERENCES

1. ANSI®/NFPA® 70 – National Electrical Code® (NEC®)
2. CSA® C22.2 No. 14-M91 – Industrial Control Equipment
3. IEC 61000 – Electromagnetic Compatibility
4. NEMA – National Electric Manufacturers Association
   a. NEMA 250 – Enclosures for Electrical Equipment
   b. NEMA ICS7 – Industrial Control and Systems Adjustable Speed Drives
   c. NEMA ICS 7.1 – Safety Standards for Construction and Guide for Selection Installation and Operation of Adjustable Speed Drives
5. UL – Underwriters Laboratories
   a. UL® 50 – Enclosures for Electrical Equipment
   b. UL 98 – Disconnect Switches
   c. UL 507 – Electric Fans
   d. UL 508 – Industrial Control Equipment
   e. UL 508A – Standard for Industrial Control Panels
   f. UL 508C or UL 61800-5-1 – Power Conversion Equipment
   g. UL 991 – Safety Tests for Safety Related Controls Employing Solid State Devices
6. OSHA® 1910.95 – AC Drive Controller Acoustical Noise
7. IBC® – International Building Code®
8. ASCE/SEI 7® – Seismic Performance Requirements
9. ICC ES AC156 – Shake-Table Test Acceptance Criteria
11. International Organization for Standardization (ISO):
   a. ISO 9001, “Quality Management Systems - Requirements”

1.3 DEFINITIONS

A. General, Definitions: Unless specifically defined within the Contract Documents, the words or acronyms contained within this specification shall be as defined by the references listed within this specification, the Contract Documents, or, if not listed by either, by common industry practice.

1.4 SUBMITTALS

1. Submit sufficient information to determine compliance with the Contract Documents. Identify submittal data with the specific equipment tags and/or service descriptions to which they pertain. Submittal data shall be clearly marked to identify the specific model numbers, options, and features of equipment and work proposed.

2. Deviations from the Contract Documents shall be indicated within the submittal. Each deviation shall reference the corresponding drawing or specification number, show the Contract Document requirement text and/or illustration, and shall be accompanied by a detailed written justification for the deviation.

B. Product Data: Submit product data specific to each type and rating of VFD proposed to include the following:
   1. Manufacturer, supplier, and proposal specific contact information.
   2. Manufacturer’s catalog data indicating model numbers, equipment specifications and construction features including all furnished options, and accessories.
   3. VFD assembly rated input KVA and output KVA, percent efficiency, operating characteristics, and electrical characteristics.
   4. Maximum Btu heat release data and ambient cooling requirements.
   5. Enclosure type, NEMA rating, material and finishes.
   6. Certification of UL conformity

C. Shop Drawings: Submit shop drawings for each product and accessory required. Include information not fully detailed in manufacturer’s standard product data. Shop drawings shall include, but not be limited to the following:
   1. Equipment assembly. Indicate dimensions, shipping section dimensions, weights, foundation requirements, required clearances, location and size of each field connection, and mounting and installation instructions.
2. Include elementary and interconnection diagrams for power, signal, control, and communications wiring. Diagrams shall provide the minimum detail as shown for drawings in the appendix of NFPA 79. All field terminals shall be identified and updated later within the O&M data to include actual field connection information. Drawings shall not be typical, but be provided for each VFD furnished.

D. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Required working clearances and required area above and around VFDs.
   2. Show VFD layout and relationships between electrical components and adjacent structural and mechanical elements.
   3. Show support locations, type of support, and weight on each support.
   4. Indicate field measurements.

E. Operation & Maintenance (O&M) Manuals: Submit installation, operation and maintenance data to be included within operation and maintenance manuals. O&M data shall include but not be limited to the following:
   1. Manufacturer, supplier, support, and repair center specific contact information.
   2. Manufacturer’s standard operation and maintenance data assembled for each size and type of equipment furnished.
   3. All configured settings/parameters for adjustable components updated to an as-installed and commissioned stated if different from the factory default. Electronic copies of configuration files shall be provided, on media acceptable to the Owner (e.g. CD, USB stick, etc.), where these configurations can be saved as an electronic file for future upload into replaced or repaired components.
   4. List of furnished and recommended spare parts.
   5. Statement of standard Warranty

1.5 QUALITY ASSURANCE

A. Qualifications
   1. Manufacturer shall be a firm engaged in the manufacture of VFDs of types and sizes required, and whose products have been in satisfactory use in similar service for a minimum of ten years.
      a. The manufacturer shall have a valid ISO 9001 certification and an applicable quality assurance system that is regularly reviewed and audited by a third party registrar. Manufacturing, inspection, and testing procedures shall be developed and controlled under the guidelines of the quality assurance system.
      b. The manufacturer or their representative shall have service, repair, and technical support services available 24 hours 7 days a week basis.
      c. The VFD manufacturer shall have the Environment Certification ISO 14001 for EcoDesign.
   2. Installer Qualifications: Installer shall be a firm that shall have a minimum of ten years of successful installation experience with projects utilizing variable frequency motor
controllers similar in type and scope to that required for this Project and shall be approved by the manufacturer's representative.

3. Startup and Training: VFDs shall be inspected, configured, and tested by a factory trained representative of the VFD manufacturer. VFD operation and maintenance training shall be conducted by a factory trained representative of the VFD manufacturer trained in the installation, operation, and maintenance of the VFD.

B. Regulatory Requirements: Comply with applicable requirements of the laws, codes, ordinances, and regulations of Federal, State, and local authorities having jurisdiction. Obtain necessary approvals from such authorities.

1. Without limiting the generality of other requirements of this Section, all work specified herein shall conform to or exceed the applicable requirements of the following standards; provided, that wherever the provisions of said publications are in conflict with the requirements specified herein, the more stringent requirements shall apply:
   a. ANSI/NFPA 70: National Electrical Code
   b. EN61800-5: Electronic equipment for use in power installation
   c. CSA C22.2 No. 14-M91: Industrial Control Equipment
   e. IEC 146.1: Semiconductor Converters – General Requirements and Line Commutated Converters Part 1-1: - Specifications of Basic Requirements
   f. IEC 664: Insulation Co-ordination for Equipment within Low-Voltage Systems
   g. IEC 447: Man-Machine Interface Actuating Principles
   h. IEC 439 Part 1: Low Voltage Switch gear and Control gear Components
   i. IEC 364: Electrical Installation of Buildings
   j. IEC 204/NFPA 79: Electrical Equipment of Industrial Machines/Industrial Machinery
   k. IEC 106: Guide for Specifying Environmental Conditions for Equipment Performance Rating
   l. IEC 529: Degrees of protection provided by enclosure
   m. IEC 1000: Electromagnetic Compatibility
   n. IEC 1800: Adjustable speed Electrical power drive systems
   o. IEC 721: Classification of Environmental Conditions
   p. IEC 255-8: Overload Relays
   q. IEC 801-2,-3,-4,-5: Immunity Tests
   r. NEMA ICS Part 4: Overload Relays
   s. NEMA ICS7: Industrial Control and Systems Variable Speed Drives
   t. UL 508C, UL 61800-5-1: UL Standard for Safety Power Conversion Equipment

C. Single Source Responsibility: Obtain VFDs and required accessories from a single source with resources to produce products of consistent quality in appearance and physical properties without delaying the work. Any materials which are not produced by the manufacturer shall be acceptable to and approved by the manufacturer.

1.6 SPECIAL TOOLS AND SPARE PARTS

A. The Contractor shall provide a recommended spare parts list with the following information provided as a minimum:

1. Contact information for the closest parts stocking location to the Owner.
2. Critical spare parts shall be identified as those parts being associated with long lead times and/or those being critical to the unit's operation.

3. Maintenance spares shall be identified as being those parts required to regularly perform scheduled maintenance on the VFD equipment. These spares shall include, but shall not be limited to, consumable spares that are required to be exchanged during scheduled maintenance periods.

B. Spare parts shall be properly marked and packaged for long term storage. Printed circuit boards shall be provided in separate anti-static containers.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Prior to delivery to the Project Site, ensure that suitable storage space is available to store materials in a well-ventilated area protected from weather, moisture, soiling, extreme temperatures, humidity, and corrosive atmospheres. Materials shall be protected during delivery and storage and shall not exceed the manufacturer stated storage requirements.

B. Unless specified otherwise, preparation for shipment shall be in accordance with manufacturer’s standards for the particular shipping method and end destination. Equipment shall be handled and stored in accordance with the manufacturer’s instructions. One copy of these instructions shall be included in the equipment at the time of shipment.

C. Inspect and report any concealed damage or violation of delivery storage, and handling requirements to the Engineer.

1.8 WARRANTY

A. The manufacturer warrants and guarantees that the supplied VFDs are not defective and shall provide warranty to include all parts, labor, and travel expenses associated with the repair of any defects for a period of 12 months after the Owner utilizes the equipment or partial/substantial completion has been attained - whichever comes first. This warranty shall be in addition to any provided by the Contractor. The warranty shall exclude normal wear and tear under normal usage and any damage caused by abuse, modification, or improper maintenance by entities other than the manufacturer or its approved representative.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Altivar 660, by Schneider Electric. (or approved equal)

2.2 SYSTEM REQUIREMENTS

A. Variable Frequency Drives (VFDs) shall provide for the starting and speed control of standard IEC or NEMA design AC inverter duty asynchronous motors and synchronous motors with permanent
magnets by the adjustment of output voltage and frequency. The VFD shall be a digitally controlled drive, using Pulse Width Modulation (PWM).

B. Unless otherwise specified or shown within the Contract Documents, the Contractor shall be responsible for matching the VFD to the load (variable or constant torque) as well as the speed and current of the actual motor being controlled. This sizing shall match the KVA and inrush characteristics of the motors provided.

C. The VFDs shall be built to comply with the UL standard and shall be marked in accordance with UL 508, UL508C or UL 61800-5-1.

D. The VFD manufacturer shall design the device with more than 70% of recyclability rate. The VFD shall be compliant with the “Green” Premium label (REACH, RoHS-2, EOL, and PEP). The VFD Manufacturer shall design the device according to the IEC 62635 guidelines to reduce the carbon footprint. The materials used in the VFD shall be recyclable, non-toxic and flame retardant. The VFD manufacturer shall provide the carbon footprint of the devices.

2.3 PERFORMANCE REQUIREMENTS

A. Performance Requirements

1. The VFD shall be rated for the nominal input voltage specified or shown on the drawings. The VFD shall have a three-phase input voltage tolerance within the following range of the corresponding nominal input voltage:
   a. 200V -15% 240V +10%
   b. 380V -15% 480V +10%
   c. 500 to 690V -15% / +10%

2. The VFD shall meet the following minimum operating requirements:
   a. Rated Frequency: 50 Hz -5% to 60 Hz + 5
   b. Displacement Power Factor: ≥0.97
   c. Efficiency:
      1) >98 % at nominal load for VFD (IP 21 / UL Type 1)
      2) >97.5 % at nominal load for enclosed VFD systems.
      3) >96 % at nominal load for low harmonic VFD(IP 21 / UL Type 1)
      4) >95.5 % at nominal load for low harmonic enclosed VFD systems.
   d. Overload Capability: Normal duty at 110% nominal current for 1 min
   e. Harmonics Mitigation: <5% at VFD input terminals at 80-100% load
   f. Surge immunity according to IEC/EN 61000-4-5 Level 3

3. The VFD shall provide a speed range in the motor quadrant 1:100 in sensor less vector control and in the generator quadrant 1:50 in sensor less vector control.

4. The VFD shall provide an over torque capability better than 110% of the rated motor torque for normal duty applications during 60s, every 10 minutes.

5. The VFD shall provide a speed accuracy ±10% of the nominal slip of the motor in sensor less vector control

6. The VFD shall provide a torque control accuracy ±15% in sensor less vector control for AC motors

B. Environmental
1. The VFD shall be rated to withstand the following environmental conditions while able to give a 100% output current continuously. Where derating is necessary to meet on site environmental conditions, the manufacturer shall submit the VFDs derated performance. The derating factor shall be specified so that neither the lifetime of the VFD nor the unit’s performance, overload capability included, nor the reliability of the VFD shall suffer.
   a. Storage Temperature: -40°C to 70°C,
   b. Operating Temperature for UL Type 1 VFDs: -15°C to 50°C without derating, up to 60°C with derating of power stage (UL Type 1)
   c. Operating Temperature for enclosed VFDs: 0°C to 40°C without derating, down to -10°C with enclosure heater, up to 55°C with derating of power stage
   d. Relative Humidity: ≤95% relative humidity without condensation per IEC 60068-2-3
   e. Operating Altitude: ≤1000m without derating, up to 4800m with derating.
   f. Corrosion Protection Level: Class 3C3 according to IEC 60721-3-3 for cooling air and chemical gases
   g. Biological Protection Level: Class 3B1 according IEC 60721-3-3
   h. Dust Protection Level: Class 3S3 according to IEC 60721-3-3
   i. Vibration and Shock Protection Level: Class 3M3 according to IEC 60721-3-3

2. The VFDs shall have an integral enclosure that shall protect from ingress of dirt and water in accordance with as shown on drawings. The user interface terminal shall be rated UL Type 12, mounted on front face of enclosure, and accessible for programming and controls with the main door closed.

3. VFD enclosures shall be front cabinet accessible and constructed in conformance with IEC 60439-1. Conduit entry shall be bottom entry as standard to allow for top mounted cooling components. The VFD enclosure shall have a forced air and heat sink cooling system that does not require liquid or air condition cooling components for ambient temperatures within the drives stated ambient temperature operating range.

2.4 APPLICATION REQUIREMENTS

1. The VFD shall provide a Real Time Clock management with battery backup.

2. The VFD shall be capable of automatic tuning of motor parameters through measurement of the motor without rotation, and without the need to disconnect the load from the motor.

3. The VFD shall provide functionality adjustable within the drive parameters to reduce voltage surges on motor cables.

4. The Contractor shall provide AC chokes and filters to fit installation and motor requirements per the following guidelines:
   a. Voltage reflection suppression for motors compliant to IEC60034-25 or NEMA MG1 Part 31
      1) Unshielded motor cable length up to 500 feet (150 meters) shall be managed with the VFD functionality
      2) Unshielded motor cable length up to 1000 feet (300 meters) an AC choke shall be required
      3) Unshielded motor cable length up to 1640 feet (500 meters) a dV/dt filter shall be required
      4) Unshielded motor cable length up to 3280 feet (1000 meters) a Sinus filter shall be required
   b. Voltage reflection suppression with motors not compliant to IEC60034-25 or NEMA MG1 Part 31
      1) Unshielded motor cable length up to 50 meters a dV/dt filter shall be required
VARIABLE FREQUENCY MOTOR CONTROLLERS

2) Unshielded motor cable length up to 1000 meters a Sinus filter shall be required

B. Protection
1. The VFD shall be UL 508 or UL61800-5-1 listed for use on distribution systems.
2. 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: 65 kAIC
3. Micro-short voltage sag immunity per SEMI F47.
4. Upon power-up the VFD shall automatically test for valid operation of memory, option module, loss of analogue reference input, loss of communication, DC to DC power supply, control power and the pre-charge circuit.
5. The VFD shall be protected against short circuits, between output phases and ground and the logic and analogue outputs.
6. The VFD shall have a selectable ride through function that will allow the logic to maintain control for a minimum of one second without tripping.
7. The deceleration mode of the VFD shall be programmable for normal and trip conditions. The stop modes shall include freewheel stop, fast stop.
8. 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 settings or last speed.
9. The VFD shall integrate a protection against IGBT and heat sink over temperature.
10. The VFD shall have solid state thermal protection that is UL Listed and meets UL 508C as a Class 10 overload protection and meets IEC 947.
11. The VFD shall have a motor thermal memory retention function per UL requirements.
12. The VFD shall be able to protect the motor when temperature probes are connected.
13. The VFD shall be able to limit the motor surge (I dv/dt) at twice the DC bus voltage
14. The VFD shall provide IGBT protection
   a. IGBT overcurrent protection
   b. IGBT check up sequence
   c. IGBT check up sequence before PWM enable sequence
   d. IGBT over-heat protection
15. The VFD shall provide VFD Current protection
   a. Phase short circuit protection
   b. Ground protection
   c. Over-current protection
16. The VFD shall provide VFD Voltage error protection
   a. Mains over-voltage protection
   b. Mains under-voltage protection
   c. DC Bus over-voltage protection
   d. DC Bus pre-charge protection
17. The VFD shall provide VFD Thermal protection
   a. VFD over-temperature protection
   b. FAN management
   c. Switching Frequency management
18. The VFD shall provide internal error detection.
19. The VFD shall provide Motor protection functions  
   a. Motor output phase detection  
   b. Motor surge voltage  
   c. Motor over load detection  
   d. Motor stall protection  
20. The VFD shall provide Application protection functions  
   a. Catch on fly function  
   b. Mains input phase lost protection  
   c. Motor over-speed input protection  
   d. Current limitation  
   e. Power limitation  
   f. Reverse inhibition  
   g. Under-load protection  
   h. Over-load protection  
   i. External error management  
   j. Loss of follower signal  
   k. Thermal Sensor management  
   l. PID Feedback  
   m. Customer defined input

C. Indicators  
1. The VFD shall display a signal by LED near the connection point of the device when a hazardous voltage is present.  
2. The VFD shall have 3 LEDs for local diagnostics.  
3. The VFD shall have 3 dual color LEDs for embedded communication status.  
4. The VFD shall have 4 dual color LEDs for optional communication status

D. User Interface  
1. 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 door mounting for the user interface shall be done with a 22 mm hole.  
2. A “Simply Start “menu for fast and easy commissioning shall be provided and parameter setting shall be easily accessible and user friendly with plain text messaging and actual setting range.  
3. The keypad shall be capable of providing password protection.  
4. The user interface shall be capable of saving and downloading configurations of the VFDs, as well as porting them to other VFDs.  
5. The user interface shall offer a Mini-USB port for mass storage or PC device connection.  
6. The mechanical mounting for the user interface on the cabinet shall be done with a 22 mm hole.  
7. The VFD shall have self-diagnostic capabilities to display alarms, errors, and warnings as they occur and be able to store at least 15 last messages into the memory. These shall be accessible by PC maintenance tools or web server with flash record for data logging expertise.
8. The user interface shall be identical throughout the power range to avoid confusion amongst
the users and need for training in several different units.

9. The displayed messages shall be in plain text English.

E. Control Interface:

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

2. The speed command and reference may come from different control sources:
   a. I/O terminals
   b. Communication network
   c. Web server
   d. Remote graphic display terminal

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

4. Programmable analog inputs shall be able to be assigned the following parameters:
   a. Speed reference
   b. Summing reference
   c. Subtracting reference
   d. Multiplying reference
   e. Torque reference
   f. Torque limitation
   g. PID feedback
   h. Manual PID reference
   i. PID speed reference
   j. Forced local reference

5. Programmable analog outputs shall be able to be assigned the following parameters:
   a. Motor current
   b. Motor frequency
   c. Motor torque (signed or unsigned)
   d. Motor power
   e. Motor voltage
   f. Output frequency (signed or unsigned)
   g. PID error
   h. PID feedback
   i. PID output
   j. PID reference
   k. Ramp output
   l. Signed ramp
6. Programmable discrete inputs shall be able to be assigned the following parameters:
   a. Run
   b. Forward
   c. Reverse
   d. Jog
   e. Preset speeds
   f. Reference switching
   g. Ramp switching
   h. Error reset
   i. Error inhibition
   j. Product reset
   k. PID regulation mode (auto)
   l. PID speed regulation mode (manual)
   m. PID integral reset
   n. Preset PID reference
   o. Sleep/wake-up
   p. Activate sleep mode by flow detection
   q. Analogue torque limitation activation
   r. Torque reference sign
   s. Command switching
   t. Parameter sets selection
   u. Fast stop
   v. DC injection
   w. Freewheel stop
   x. + speed
   y. - speed
   z. External error
   aa. Pre Fluxing
   bb. Forced local control
   cc. Current limitation activation
   dd. Output contactor feedback
   ee. Reference memorization
   ff. Auto-tuning
   gg. Forced operation
   hh. Under load detection
   ii. Overload detection
   jj. Limiting low speed operating time
   kk. Switching frequency, noise reduction
   ll. Drive lock assignment
   mm. Outlet pressure switch select
   nn. Pipe fill
   oo. External anti jam trigger
   pp. Dry running no flow switch select
   qq. Pump low flow no flow switch select

7. Programmable discrete outputs shall be able to be assigned the following parameters:
   a. Ready
   b. Drive running
c. Frequency reference attained
d. Current attained
e. High speed attained
f. Drive error
g. Frequency threshold attained
h. Torque sign
i. Motor thermal state attained
j. Drive thermal state attained
k. Torque or current limitation attained
l. Output contactor command
m. Input contactor command
n. Current present
o. Power removed
p. Alarm Groups
q. Alarms: load slipping, 4-20mA loss, brake control, external error, PTC, PID error, PID feedback, IGBT temperature, under voltage, torque control, drive temperature, braking resistor, fan counter, fan feedback, customer warning, power threshold, electrical power drift
r. Active configuration
s. Active parameter set
t. Active channel
u. DC bus charged
v. DC bus charging
w. Water Command: jockey pump, priming pump
x. Water running: anti-jam, pipe fill, priming pump, jockey pump
y. Water warning: dry running, flow, inlet pressure, outlet pressure, pump cycling, anti-jam, outlet pressure switch,

8. Safety Inputs
a. The VFD shall provide 2 inputs dedicated to Safe Torque Off (STO) safety function, which prohibits unintended equipment operation, in accordance with IEC/EN 61508-1 SIL3.
b. The VFD shall be compliant with EN13849 (PL e).
c. The VFD shall be compliant with safety of machinery EN 954-1
d. 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.
e. The VFD shall integrate the safety contacts in compliance with EN-81 13.2.2.3

F. Communications

1. The VFD shall provide at a minimum 1 Modbus and 1 Ethernet Modbus TCP communications ports. In addition the following communications options shall be provided as necessary for communications. Refer to communication requirements specified elsewhere within the Contract Documents.
   a. Ethernet IP or Modbus TCP, RJ45 dual port for daisy chain

2. VFD Ethernet ports shall be IPv6 compliant, allow for web server access and provide network management via SNMP and clock synchronization.

3. The VFD shall provide an embedded web server for enhanced diagnostic, configuration, parameter access, and energy management. There shall be the capability to create a user-defined custom dashboard for viewing drive and process status through tables, charts, and graphical views. It shall be possible to export data in standard table format using the webserver, for information around energy consumption as well as error and warning history.
4. The VFD shall be compliant with the Cyber Security Management ISA Secure /Achilles.
5. The VFD shall be capable of providing Wi-Fi connectivity via option for wireless diagnostic, configuration, and parameter access.
6. The VFD shall provide integration connectivity via
   a. DHCP protocol for Fast Device Replacement
   b. DTM library in compliance with standard FDT technology

G. Configuration

1. The VFD shall be capable of accepting independent command and speed reference signals from:
   a. Terminals
   b. Modbus port
   c. Ethernet port
   d. Communication option card
   e. Keypad display.
2. The VFD shall provide a Speed set-point function capable of:
   a. Maximum output frequency function
   b. Low and High speed scaling and limitation function
   c. Jump frequency
   d. Speed summing references function
   e. Preset-speed references function
   f. Jog function
   g. Up-Down speed references
3. The VFD shall provide a Stop function capable of:
   a. Deceleration ramp on power loss
   b. Freewheel stop
   c. Stop by DC injection at motor stop detection
   d. Stop by DC injection by Logic Input
   e. Stop on deceleration ramp adaptation
4. The VFD shall have an acceleration/deceleration, time adjustable ramp function capable of:
   a. Ramp type: linear ramp, S shape ramp, with U or customized profile.
   b. Ramp Deceleration adaptation
   c. Ramp switching
5. Application programming dedicated to pumps
   a. The VFD shall provide Pump Control & Monitoring Functions
      1) Centrifugal pump characteristics and configurations.
      2) Pump monitoring function in order to define data relevant for pump (acceleration, low speed, high speed, etc.)
      3) Application Units function in order to define units used in applications
      4) Pump Cyclic Start Protection in order to protect the pump against too many restarts in a dedicated time period.
      5) Multi-pump functions.
   b. The VFD shall provide Pump Protection Functions
      1) Anti-Jam function in order to remove automatically clogging substances from the pump impellers.
      2) Pipe Cleaning function in order to start pump regularly to avoid sedimentation in pump impeller
      3) Cavitation Pump Protection
4) Inlet protection in order to avoid system dry running.

c. The VFD shall provide Application control functions
   1) Stop and Go function in order to reduce consumption of VFD in case of pump doesn't work
   2) Pulse input in order to connect a flow meter.
   3) Process control (PID) function in order to maintain a process at a given pressure or flow reference.
   4) Flow limitation function in order to allow limiting the consumption of water.
   5) Friction loss compensation function in order to compensate pressure losses in pipes due to friction.
   6) Pipe Fill function in order to manage a smooth control during pipe filling and to lessen the effects of water hammer.
   7) Sleep wake-up function in order to manage periods of the application when process demand is low and when it is not needed.
   8) Low demand function in order to define periods of the application when process demand is low in order to save energy.
   9) 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.
  10) Sensor management in order to define how will be used drive inputs to manage Pressure sensor or flow sensor

d. The VFD shall provide Application protection functions
   1) High flow protection function in order to detect pipe burst or detect running outside normal working area
   2) Outlet pressure protection function in order to fix minimum and maximum pressure.

e. The VFD shall provide Pump curve input to help optimize pump performance.
   1) Input and storage of the pump characteristics including 5 points of the pump curve.
   2) A best efficiency point (BEP) function in order to run in optimum conditions and detect deviation from this point.

H. Diagnostics and Configuration

  1. 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 drive, read actual values and make trend analysis using the software. The PC-tools may be connected to the VFD by wired or wireless connection.
  2. The VFD shall display all faults in plain text and help screens shall be available to guide the user in the troubleshooting. Codes are not acceptable.
  3. The VFD shall provide a Real Time Clock management for time stamping of detected errors.
  4. The VFD shall display detected errors with QR codes to guide the user in the troubleshooting.
  5. The VFDs must provide LED lights to indicate the status of the VFD.
  6. The VFD must have the ability to dynamically display I/O status.

I. Energy Management

  1. The VFD shall provide a data logging function in order to keep files ready for maintenance or user.
2. The VFD shall provide information related to Energy management through different ways such as: web server, keypad, facet for SCADA, communication networks.

3. The user interface shall be able to display a chart relative to energy efficiency and energy management.
   a. Report in KW
   b. Display energy history for instant, weekly, monthly, and yearly.
   c. Trend base on variation /time
   d. All power measurement precision must be less than 5 % of deviation.

4. The user interface shall be able to display the “efficient” set point for pump based on pump characteristics.

5. The user interface shall be able to display the “efficiency board” including CO2 savings, Savings viewer, and Return of Investment.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine 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 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 are 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 onsite to include any settings / parameters not identified as factory defaults within 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. Contractor shall conduct performance verification tests in the presence of Government representative, observing and documenting complete compliance of the system to the specifications. 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 factor-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 6 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

END OF SECTION
The attached Geotechnical Information is provided for information purposes only, and is indicative only of materials and groundwater conditions which exist at the exact location of the drilling hole and time of the boring. None of the boring logs, soils reports, groundwater analysis, or other materials contained herein are to be construed as a representation of actual subsurface conditions.

The location description of borings provided on the boring logs are approximate.

Any Bidder or Contractor making use of this information in the preparation of his bid or in the construction of the project does so at his own risk and liability. Neither the Engineer nor the Owner make any assurances or guarantees regarding the information contained herein.
A Report Prepared for:

Mr. Jason Ray
Holloway, Updike & Bellen, Inc.
905-A South 9th Street
Broken Arrow, Oklahoma 74012

GEOTECHNICAL ENGINEERING REPORT
PROPOSED AIRPORT LIFT STATION AT
NORTHSIDE WASTEWATER TREATMENT PLANT
5628 NORTH 105TH EAST AVENUE
TULSA, OKLAHOMA

Prepared by:

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Staff Professional I

Reviewed by:

Karthik Radhakrishnan, PE
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Fax: 918.627.6262

November 7, 2018
Kleinfelder Project No. 20192112.001A
November 7, 2018
Kleinfelder Project No.: 20192112.001A

Mr. Jason Ray
Holloway, Updike & Bellen, Inc.
905-A South 9th Street
Broken Arrow, Oklahoma 74012

Subject: Geotechnical Engineering Report
Proposed Airport Lift Station At
Northside Wastewater Treatment Plant
5628 North 105th East Avenue
Tulsa, Oklahoma

Dear Mr. Ray:

Kleinfelder has completed the authorized subsurface exploration and geotechnical engineering evaluation for the above-referenced project. The services were provided in general accordance with our proposal No. TUL18P76117, dated April 4, 2018. The purpose of the geotechnical study was to explore and evaluate the subsurface conditions, perform analysis, and provide design and construction recommendations for the proposed airport lift station at Northside Wastewater Treatment Plant located at 5628 North 105th East Avenue in Tulsa, Oklahoma. The attached Kleinfelder report contains a description of the findings of our field exploration and laboratory testing program, our engineering interpretation of the results with respect to the project characteristics, and our geotechnical site development recommendations as well as construction guidelines for the planned project. Recommendations provided herein are contingent on the provisions outlined in the ADDITIONAL SERVICES and LIMITATIONS sections of this report. The project owner should become familiar with these provisions in order to assess further involvement by Kleinfelder and other potential impacts to the proposed project.

We appreciate the opportunity to be of service to you on this project and are prepared to provide the recommended additional services. Please call us if you have any questions concerning this report.

Sincerely,
KLEINFELDER, INC.
Certificate of Authorization #7292, Expires 6/30/19

Bobby Goben
Staff Professional I

Karthik Radhakrishnan, PE
Senior Project Manager
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FIGURES
Figure 1 – Exploration Location Plan and Vicinity Map

APPENDICES
A Field Exploration Program
B Laboratory Testing Program
C GBA Document
1.1 GENERAL

Kleinfelder has completed the authorized subsurface exploration and geotechnical engineering evaluation for the proposed airport lift station at Northside Wastewater Treatment Plant located at 5628 North 105th East Avenue in Tulsa, Oklahoma. The services were provided in general accordance with our proposal No. TUL18P76117, dated April 4, 2018.

This report includes our recommendations related to the geotechnical aspects of the project design and construction. Conclusions and recommendations presented in the report are based on the subsurface information encountered at the location of our exploration and the provision and requirements outlined in the ADDITIONAL SERVICES and LIMITATIONS sections of this report. In addition, an article prepared by The Geoprofessional Business Association (GBA), *Important Information about This Geotechnical Engineering Report*, has been included in APPENDIX C. We recommend that all individuals read the report limitations along with the included GBA document.

1.2 PROPOSED CONSTRUCTION

Based on the information provided to us by Holloway, Updike & Bellen, Inc., we understand that the City of Tulsa is planning to build a new lift station at the southeast side of the existing Northside Wastewater Treatment Plant just west of the lagoons, located at 5628 North 105th East Avenue in Tulsa, Oklahoma. Based on the information provided by Holloway, Updike, and Bellen, Inc. (HUB), the proposed structure will be Cast-In-Place (CIP) concrete with a footprint of approximately 35 feet wide by 60 feet long and will bear approximately 30 feet below existing grade. Top of wet well structure will be at elevation 581.0 feet with the bottom of footing at elevation 550.50 feet. No structural loads, grading plans or any other information were provided. HUB located two boring locations at the site for the purposes of geotechnical investigations.
The scope of the exploration and engineering evaluation for this study, as well as the conclusions and recommendations in this report, were based on our understanding of the project as described above. If pertinent details of the project have changed or otherwise differ from our descriptions, we must be notified and engaged to review the changes and modify our recommendations, if needed.
2 SITE CONDITIONS

2.1 SITE DESCRIPTION

The project site is located at 5628 North 105th East Avenue in Tulsa, Oklahoma. The general location of the site is shown in Figure 1, Exploration Location Plan and Vicinity Map. The project site can be accessed from East 56th Street North through paved service road. The proposed structure will be located on the southeast side of the plant. In general, the project site area is covered with grass and surrounded by the wastewater treatment plant, Bird Creek, open grass fields, and heavily wooded areas. Existing overhead and underground utilities were noted within the current right-of-way during our field exploration. Additional utilities are anticipated within the proposed construction area.

2.2 SUBSURFACE CONDITIONS

Kleinfelder explored the subsurface conditions at the site by drilling and sampling two borings (designated as B-1 and B-2), at the locations provided by Holloway, Updike & Bellen, Inc. Approximate boring locations are shown in Figure 1, Exploration Location Plan and Vicinity Map. The borings were advanced to approximate depths of 30 feet below existing ground surface. The field exploration and laboratory testing programs are presented in APPENDIX A and APPENDIX B, respectively.

The following presents a general summary of the major strata encountered during our subsurface exploration and includes a discussion of the results of the field and laboratory tests conducted. Specific subsurface conditions encountered at the boring locations are presented on the respective boring log in APPENDIX A. The Subsurface Cross Section, Figure A-1 in APPENDIX A, depicts the generalized subsurface profile across the project site based on the information obtained from the borings. The stratification lines shown on the boring logs and subsurface cross section represent the approximate boundaries between material types; in-situ, the transitions may vary or be gradual.

The borings were drilled to depths of approximately 28.5 to 30 feet below existing grade. In general, the subsurface materials in the borings consisted of both lean and fat clay with variable sand underlain by limestone bedrock to the boring termination depths. Limestone was
encountered at depths ranging from 28.5 feet below the ground surface in boring B-1 to a maximum of 29.5 feet below ground surface in boring B-2. Bedrock in all borings continued to termination depths of the borings. The soils were dark gray in color. The consistency of the clay materials encountered were generally soft to very stiff.

2.3 GEOLOGY DESCRIPTION

According to the "Engineering Classification of Geologic Materials – Division Eight" from the Oklahoma Highway Department, 1970, the project site appears to be located within, **Alluvium Unit (Qas)**.

**Alluvium Unit (Qas)**: This unit consists of deposits of sand, silt, clay, gravel, and/or combinations of materials. Alluvium is found along the flood plains (bottom land) of streams and is normally present at places along all streams.

2.4 GROUNDWATER OBSERVATIONS

Groundwater observations were made during drilling and at the end of the drilling. Table 2-2 summarizes the depths and elevations of the groundwater observations during drilling operation and at the end of drilling operations.

<table>
<thead>
<tr>
<th>Boring No.</th>
<th>Ground Elevation (feet)</th>
<th>Groundwater Depth while Drilling (feet)</th>
<th>Groundwater Elevation while Drilling (feet)</th>
<th>Groundwater Depth 1 Hour After Drilling (feet)</th>
<th>Groundwater Elevation After Drilling (feet)</th>
</tr>
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<tbody>
<tr>
<td>B-1</td>
<td>579.5</td>
<td>18.5</td>
<td>561</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>B-2</td>
<td>579.5</td>
<td>18.5</td>
<td>561</td>
<td>10</td>
<td>569.5</td>
</tr>
</tbody>
</table>

The materials encountered in the test borings have a wide range of permeabilities, and water level observations over an extended period of time through use of piezometers or cased borings would be required to better define groundwater conditions. Groundwater is likely perched at the bottom of the fill section and above the bedrock, especially during rainy seasons. Fluctuations of groundwater levels can occur due to seasonal variations in the amount of rainfall, runoff, and other factors not evident at the time the borings were performed. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.
2.5 LABORATORY TESTING

Atterberg limits tests performed on selected soil samples indicated liquid limit (LL) values ranging from 26 to 57, plastic limit (PL) values ranging from 15 to 25, and plasticity index (PI) values ranging from 11 to 32. Grain size analysis results indicated that the fines content (percentage by weight passing the #200 sieve) of the soil ranged from approximately 73 to 94 percent. The moisture content of the samples ranged from approximately 14.2 to 28.3 percent. Chloride, pH, and sulfate tests were conducted on one sample from each boring (B-1 and B-2). A more detailed discussion about the laboratory testing program is presented in APPENDIX B.
3 CONCLUSIONS AND RECOMMENDATIONS

3.1 GENERAL

Based on our evaluation, the proposed project is feasible from a geotechnical standpoint. The subsurface conditions encountered are typical of subsurface conditions within this area and do not represent unique or anomalous conditions. The primary concerns for this project, with respect to the subsurface conditions encountered in the borings is the groundwater at the proposed project site. It is elaborated further in Section 4 of this report.

The recommendations submitted herein are based, in part, upon data obtained from our subsurface exploration. The nature and extent of subsurface variations that may exist at the proposed project site will not become evident until construction. If variations appear evident, then the recommendations presented in this report should be evaluated. In the event that any changes in the nature, design, or location of the proposed project are planned, the conclusions and recommendations contained in this report will not be considered valid unless the changes are reviewed, and our recommendations modified in writing.

3.2 DESIGN RECOMMENDATIONS

3.2.1 Foundation recommendations

Our design recommendations were developed based on the information provided to us by Holloway, Updike & Bellen, Inc. The recommendations for design and construction of concrete mat foundation are presented in the following sections.

3.2.2 Recommendations For Proposed New Lift Station Mat Foundation

Based on our engineering analysis, the proposed new wet well structure can be supported on mat/slab foundation system. The mat/slab foundation should be supported on the shale/limestone bedrock or on at least 3 feet of compacted aggregate base layer.

A design subgrade modulus of 100 pounds per cubic inch (pci) is recommended for use in design for the mat foundation. It is to be noted that a value of 100 pci represents the modulus of subgrade reaction assuming a 1-foot square plate. This value should be corrected for the design width of
the mat. The correction can be applied generally by dividing the 1-foot square plate subgrade modulus (100) by the width of the proposed mat foundation.

The slab/mat foundation is expected to be below the groundwater table. It is our understanding that the total downward load from the lift station building and other appurtenances are adequate to counteract uplift loads due to buoyancy effects. Buoyancy effects should be calculated considering maximum flood level conditions.

Long-term structural settlement of mat foundations designed and constructed as outlined above should be minor, 1 inch or less. Differential settlement on the order of ¾-inch or less is anticipated.

3.2.2.1 Construction Considerations and Observations

Once the bottom of the foundation grades is reached, an additional over-excavation of 3 feet and replacement with 3 feet of compacted aggregate base material is recommended, for uniform support of the slab on grade unless the slab on grade are supported on competent shale or limestone bedrock. If the bottom of the foundation grades is at or below the levels of competent bedrock, the slab/mat foundation can be supported on competent bedrock. The aggregate base material should be similar in gradation to ODOT TYPE A base materials. The base of the foundation excavation should be clean and free of water and loose or disturbed material prior to placement of the grade layers. Gravel layer and concrete should be placed as soon as possible after excavating so that disturbance of the bearing materials does not occur. Should the bearing materials become disturbed, we recommend that the effected materials be removed prior to placing concrete.

It is recommended that the foundation excavation be evaluated and tested by the geotechnical engineer immediately prior to placement of concrete. Unsuitable areas identified at this time should be corrected. Corrective procedures would be dependent upon conditions encountered and may include deepening of the foundation element or undercutting of unsuitable materials and replacement with lean concrete.
3.2.3 Below Grade Wall Recommendations

3.2.3.1 Lateral Earth Pressures

We understand that below-grade walls will be constructed in conjunction with the new lift station building construction. Below grade walls subjected to lateral earth pressure should be designed for the at-rest stress condition (i.e., no wall rotation is allowed) using an ultimate equivalent fluid unit weight of 100 pounds per cubic foot (pcf), based on a coefficient of at-rest earth pressure of 0.59 with a soil unit weight of approximately 125 pcf. The recommended lateral earth pressure includes the effect of hydrostatic forces and buoyant unit weight of soils. Backfill should be placed and compacted as recommended in STRUCTURAL FILL section of this report. Over-compaction will result in excessive lateral earth pressures. These load distributions do not include a factor of safety. Also, these stress distributions do not include the influence of foundations, pavements, or other surcharges located in or adjacent to wall backfill, and/or sloping backfill. The below grade wall footings will bear approximately 30 feet below existing grade.

3.2.4 Seismic Hazard Determination

Based on the subsurface information, the project site would be characterized as a Site Class “D” per the 2012 International Building Code (IBC). In addition, there is no significant risk of liquefaction or mass movement of the on-site soils due to a seismic event.
4 SITE DEVELOPMENT

4.1 PRIMARY GEOTECHNICAL CONCERNS

4.1.1 Groundwater

The site subsurface conditions increase the potential for the development of perched groundwater conditions. In a “perched” groundwater condition, precipitation will infiltrate the upper more permeable soils and sit (perch) on the underlying less permeable clay soils. It is anticipated that once the materials subject to perched water are exposed, these soils will become unstable and will pump, and be easily disturbed. Prior to placement of structural fill, undercutting of unstable soils maybe required. In addition, temporary de-watering may be required to lower the ground water below the exposed subgrade materials. Lowering the groundwater will help in providing stable subgrade for receiving fill.

4.2 SITE DEVELOPMENT

4.2.1 Stripping, Undercutting and Evaluation of Existing Fill

Site preparation should commence with the stripping of all vegetation, topsoil, and evaluation of existing fills. The depth and extent of the undercutting or possible stabilization methods will be dependent on observations made in the field at the time of construction and should be adjusted to remove all vegetation, root systems, and existing unsuitable fill. A representative of Kleinfelder should monitor the stripping operations to observe that all unsuitable materials have been removed. Soft or unstable areas should be undercut and replaced with structural fill. If required, the exposed grade should be moisture conditioned prior to placement of structural fill. Soils removed during site stripping operations could be used for final site grading within the landscaped areas.

4.2.2 Utilities

Relocation of any existing utility lines within the zone of influence of proposed construction areas should also be completed as part of the site preparation. The lines should be relocated to areas outside of the foundation zone of influence. The zone of influence is within 2 feet beyond the edge of the footing and projecting downward at a 2 Horizontal to 1 Vertical, 2(H) to 1(V) slope. Care should be taken during construction to avoid disturbance to or undermining in-place footings during installation of utilities. Utility excavations should be maintained in a safe condition (according to
OSHA) during placement of the lines. Excavations created by removal of the existing lines should be cut wide enough to allow for use of heavy construction equipment to compact the backfill. In addition, the base of the excavations should be thoroughly evaluated by a geotechnical engineer or engineering technician prior to placement of backfill. All backfill should be placed in accordance with the recommendations presented in the STRUCTURAL FILL section of this report.

Existing utility lines may be located within the proposed construction areas. The depth of the lines or lateral extent of the backfill is currently unknown. It is anticipated that much of the material has relatively low consistencies and densities. If the lines are to be left in place, thorough evaluation of the backfill will be required. Evaluation should consist of excavating test pits into the backfill to determine the condition and composition of this material. If unsuitable material is encountered, it should be undercut and replaced with controlled structural fill.

4.2.3 Proofrolling

Following moisture conditioning, it is recommended that the exposed grade in fill areas and structure areas be proofrolled. Proofrolling of the subgrade provides a more stable base for placement of structural fill and aids in identifying soft or disturbed areas. Unsuitable areas identified by the proofrolling operation should be undercut and replaced with structural fill. Proofrolling can be accomplished through use of a fully-loaded, tandem-axle dump truck or similar equipment providing an equivalent subgrade loading. The subgrade should be carefully observed during the proofrolling procedure with soft or wet conditions.

4.2.4 Scarification, Moisture Conditioning, and Compaction

Prior to placement of structural fill, the moisture content of the exposed soils should be evaluated. Depending on the in-situ moisture content of the soils exposed, moisture conditioning of the exposed grade may be required prior to proofrolling and/or fill placement. The moisture content of the exposed grade in these fill areas should be adjusted to within the range recommended for structural fill, to allow the exposed material to be compacted to a minimum of 95 percent of the standard Proctor density. Extremely wet or unstable areas that hamper compaction of the subgrade may require undercutting and replacement with structural fill or other stabilization techniques. If the soils are desiccated and have a high swell potential, additional undercutting may also be required. Suitable structural fill should be placed to design grade as soon as practical after reworking the subgrade to avoid moisture changes in the underlying soils.
4.3 CLIMATIC CONDITIONS

Weather conditions will influence the site preparation required. Following periods of rainfall, the moisture content of the near surface soils may be significantly above the optimum moisture content. These conditions could seriously impede grading by causing an unstable subgrade condition. Typical remedial measures include aerating the wet subgrade, removal of the wet materials and replacing with dry materials, or following an evaluation for suitability, treating the material with cement kiln dust (CKD).

If construction of the project is to be performed during winter months, appropriate steps shall be taken to prevent the soils from freezing. In no case shall the fill or other exterior flat work be placed on or against frozen or partially frozen materials. Frozen materials shall be removed and replaced with a suitable material. Frozen materials shall not be included in any compacted fills.

4.4 TEMPORARY EXCAVATIONS

4.4.1 General

All excavations must comply with applicable local, state and federal safety regulations. The responsibility for excavation safety and stability of temporary construction slopes lies solely with the contractor. We are providing this information below solely as a service to our client. Under no circumstances should this information provided be interpreted to mean that Kleinfelder is assuming responsibility for construction site safety or the Contractors activities, such responsibility is not being implied and should not be inferred.

4.4.2 Excavations

It is anticipated that excavations for the proposed structures and utilities could be in existing fill and native soils. Excavation of the fills and the native soils should be possible with appropriately sized conventional equipment such as backhoes, loaders, etc. Temporary dewatering techniques will be required to remove any water seepage that may be encountered in shallow excavations. Excavations for removal of soils extending below or near the depth at which groundwater was encountered may require more sophisticated dewatering methods/equipment.

4.4.3 Slopes

Excavations should be cut to a stable slope or be temporarily braced, depending on the excavation depths and the subsurface conditions encountered. The contractor should be aware
that slope height, slope inclination, surcharges or excavation depths should in no case exceed those specified by local, state and/or federal safety regulations, such as OSHA Health and Safety Standard for Excavations, 29 CFR Part 1926, or successor regulations. Construction slopes should be closely observed for signs of mass movement: tension cracks at the crest, bulging at the toe, etc. If potential stability problems are observed, a geotechnical engineer should be contacted immediately.

4.4.4 Construction Considerations

Stockpiles should be placed at a minimum distance of twice the height of the excavation from the edge of the excavation and their heights should be controlled so they do not surcharge the sides of the excavation. Surface drainage should be carefully controlled to prevent flow of water into the excavations. Construction equipment should not operate near the top of the excavations. If excavations will be open for extended periods of time, measures (e.g. covering with tarps) should be considered to limit moisture changes in the exposed soils.

4.5 PERMANENT SLOPES

Permanent cut or fill slopes should be no steeper than 3(H) to 1(V) to maintain long-term stability and to provide ease of maintenance. Steeper slopes are susceptible to erosion, will be difficult to maintain, and could experience problems with instability. The crest or toe of cut or fill slopes should be no closer than 10 feet from any foundation. It is recommended that permanent slopes be vegetated, as soon as practical, in order to minimize the potential for erosion.

4.6 STRUCTURAL FILL

4.6.1 Materials

All structural fill required to achieve design grades should consist of approved materials, free of organic matter and debris. All approved structural fill placed behind below grade walls should consist of non-plastic to lower plasticity soil with a maximum Plasticity Index (PI) of 22, as determined by the Atterberg limits test ASTM D4318, wet preparation procedure. The structural fill material defined in this section is for use in backfill behind below grade walls, backfill for utility excavations and other minor grading. This structural fill may not be used to replace compacted aggregate base recommended below mat/slab foundation.
4.6.2 Compaction Criteria

Fill should be placed in lifts having a maximum loose lift thickness of 9 inches. The lift thickness may need to be reduced, depending upon the type/size of compaction equipment utilized at the site. All fill placed at the site should be compacted to a minimum of 95 percent of the material's maximum dry density as determined by ASTM D698 (Standard Proctor compaction) below the foundation area. If the plasticity index of the soils is greater than 12, the moisture content of the fill at time of compaction should be within a range of 0 percent to 4 percent above optimum moisture content as defined by the standard Proctor compaction procedure. If the plasticity index of the soils is less than or equal to 12, the moisture content of the fill at time of compaction should be within a range of 2 percent below to 2 percent above optimum moisture content as defined by the standard Proctor compaction procedure. Moisture contents should be maintained within this range until completion of the project.

4.6.3 Existing Site Soils

Based on the conditions encountered in the borings and laboratory testing results, it appears that the onsite fill materials are NOT suitable for use as structural fill material. Additional testing should be performed to verify the suitability of the onsite soils and any imported fill during construction.

4.6.4 Organic Soils

Soils with maximum 5% organic contents by weight removed during site preparation could be utilized in the upper portion of the fill sections in landscaped areas of the site. Depth of organic fill and degree of compaction should be established to provide a stable surface that will be conducive to growth of grass cover.
5 ADDITIONAL SERVICES

5.1 PLANS AND SPECIFICATIONS REVIEW

We recommend that Kleinfelder conduct a general review of the final plans and specifications to evaluate that our earthwork recommendations have been properly interpreted and implemented during design. In the event Kleinfelder is not retained to perform this recommended review, we will assume no responsibility for misinterpretation of our recommendations.

5.2 CONSTRUCTION OBSERVATION AND TESTING

We recommend that all earthworks during construction be monitored by a representative from Kleinfelder. Construction observations should include site preparation, placement of all engineered fill, and construction of the roadway subgrades. The purpose of these services would be to provide Kleinfelder the opportunity to observe the soil conditions encountered during construction, evaluate the applicability of the recommendations presented in this report to the soil conditions encountered, and recommend appropriate changes in design or construction procedures if conditions differ from those described herein.
6 LIMITATIONS

This work was performed in a manner consistent with that level of care and skill ordinarily exercised by other members of Kleinfelder’s profession practicing in the same locality, under similar conditions and at the date the services are provided. Our conclusions, opinions, and recommendations are based on a limited number of observations and data. It is possible that conditions could vary between or beyond the data evaluated. Kleinfelder makes no other representation, guarantee, or warranty, express or implied, regarding the services, communication (oral or written), report, opinion, or instrument of service provided. The scope of our services did not include any environmental assessment or exploration for the presence of hazardous or toxic materials in the soil, surface water, groundwater or air, on, below or around this site.

This report may be used only by the Client and the registered design professional in responsible charge and only for the purposes stated for this specific engagement within a reasonable time from its issuance, but in no event later than two years from the date of the report. Land use, site conditions (both on-site and off-site), regulations, or other factors may change over time, and additional work may be required with the passage of time. Any party other than the client who wishes to use this report shall notify Kleinfelder of such intended use. Based on the intended use of the report, Kleinfelder may require that additional work be performed and that an updated report be issued. Non-compliance with any of these requirements by the client or anyone else will release Kleinfelder from any liability resulting from the use of this report by any unauthorized party and client agrees to defend, indemnify and hold harmless Kleinfelder from any claim or liability associated with such unauthorized or non-compliance.

The work performed was based on project information provided by Client. If Client does not retain Kleinfelder to review any plans and specifications, including any revisions or modifications to the plans and specifications, Kleinfelder assumes no responsibility for the suitability of our recommendations. In addition, if there are any changes in the field to the plans and specifications, Client must obtain written approval from Kleinfelder’s engineer that such changes do not affect our recommendations. Failure to do so will vitiate Kleinfelder’s recommendations.
FIGURES

FIGURE 1. EXPLORATION LOCATION PLAN AND VICINITY MAP
NOTE:
BASE MAPPING AND VICINITY MAP CREATED FROM LAYERS COMPILED BY ESRI PRODUCTS AND 2018 MICROSOFT CORPORATION. COORDINATE SYSTEM: GCS WGS 1984

EXPLORATION LOCATION PLAN AND VICINITY MAP

FIGURE 1

20192112
BG
KR
11-07-2018

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THIS DRAWING IS NOT TO SCALE

PROJECT NO. DRAWN BY: CHECKED BY: DATE: REVISED:
KLEINFELDER Bright People. Right Solutions.

Proposed Airport Lift Station at Northside Wastewater Treatment Plant
5628 North 105th East Avenue
Tulsa, Oklahoma
APPENDIX A

FIELD EXPLORATION PROGRAM
APPENDIX A
FIELD EXPLORATION PROGRAM

Kleinfelder conducted the field work for this study on October 17, 2018. The exploration consisted of two borings near the locations indicated on Figure 1, Exploration Location Plan and Vicinity Map. The borings were terminated around 30 feet below the existing surface.

The representative borings were located and marked in the field by Holloway, Updike & Bellen, Inc. Locations of the borings should be considered accurate only to the degree implied by the methods used to obtain them. Table A-1 lists the approximate boring locations.

<table>
<thead>
<tr>
<th>Boring No.</th>
<th>Boring GPS Location</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-1</td>
<td>36.23686</td>
<td>-95.85555</td>
<td></td>
</tr>
<tr>
<td>B-2</td>
<td>36.23692</td>
<td>-95.85571</td>
<td></td>
</tr>
</tbody>
</table>

Representatives of Kleinfelder recorded the boring locations in the field using a handheld Global Positioning System (GPS) with a horizontal accuracy of about 15 feet. Elevations at the boring locations were not obtained. HUB provided approximate ground surface elevations at the boring locations. Locations of the borings should be considered accurate only to the degree implied by the methods used to obtain them.

Borings were drilled with an ATV-mounted (D-50) rotary drill rig using the hollow-stem augers technique to advance the boreholes. Representative samples were obtained by Shelby tube samples (ASTM D1587) and by split-barrel sampling procedures (ASTM D1586). The split-barrel sampling procedure utilizes a standard 2-inch O.D. split-barrel sampler that is driven into the bottom of the boring with a 140-pound auto-hammer (78% efficiency) falling 30 inches. The number of blows required to advance the sampler the last 12 inches of a normal 18-inch penetration is recorded as the Standard Penetration Resistance Value (N). These "N" values are indicated on the boring logs at their depth of occurrence and provide an indication of the relative density of the material.

Thin-walled Shelby tube samplers were also utilized to obtain relatively undisturbed specimen suitable for laboratory tests of physical properties. A relatively undisturbed sample is obtained by
pressing a thin-walled metal tube (typically with an outside diameter of 3 inches) into the in-situ soil by drill rig, removing the soil-filled tube, and sealing the ends to reduce the soil disturbance and moisture loss. Bedrock encountered in the borings was tested by standard SPT. The samples were sealed and returned to our laboratory for further examination, classification, and testing.

Boring logs included in this appendix present such data as soil and bedrock descriptions, consistency, relative density, and relative hardness evaluations, depths, sampling intervals, and observed groundwater conditions. Conditions encountered in each of the borings were monitored and recorded by the field engineer. Field logs included visual classification of the materials encountered during drilling, as well as drilling characteristics. Our final boring logs, as presented in this appendix, represent an interpretation of the field logs combined with laboratory observation and testing of the samples.

Visual classifications were made in accordance with the Unified Soil Classification System presented on the Graphics Key, Soil Description Key, and Rock Description Key that are also presented as figures in this appendix. The Subsurface Cross Section, Figure A-1, depicts the generalized subsurface profile across the project site based on the information obtained from the borings. Stratification boundaries indicated on the boring logs and cross section were based on observations during our fieldwork, an extrapolation of information obtained by examining samples from the borings and comparisons of soils with similar engineering characteristics. Locations of these boundaries are approximate, and the transitions between material types may be gradual rather than clearly defined.
NOTES:
REFER TO INDIVIDUAL LOGS FOR DETAILED INFORMATION AND THE GRAPHIC LEGEND KEYS FOR GRAPHICAL SYMBOL INFORMATION.

SUBSURFACE CROSS-SECTION

Proposed Airport Lift Station at Northside Wastewater Treatment Plant
5628 North 105th East Avenue
Tulsa, Oklahoma

KLEINFELDER
Bright People. Right Solutions.
### ABBREVIATIONS

**TCP** - Texas Cone Penetrometer: A 3 inch diameter by 2.5 inch long 60 pound hammer falling 30 inches.

**CALIFORNIA SAMPLER**

**STANDARD PENETRATION SPLIT SPOON SAMPLER**

**SHELBY TUBE SAMPLER**

**HOLLOW STEM AUGER**

**SOLID STEM AUGER**

**WASH BORING**

**GROUND WATER GRAPHICS**

- **WATER LEVEL** (level where first observed)
- **WATER LEVEL** (level after exploration completion)
- **WATER LEVEL** (additional levels after exploration)
- **OBSERVED SEEPAGE**

### NOTES

- The report and graphics key are an integral part of these logs. All data and interpretations in this log are subject to the explanations and limitations stated in the report.
- Lines separating strata on the logs represent approximate boundaries only. Actual transitions may be gradual or differ from those shown.
- No warranty is provided as to the continuity of soil or rock conditions between individual sample locations.
- Logs represent general soil or rock conditions observed at the point of exploration.
- In general, Unified Soil Classification System designations presented on the logs were based on visual classification in the field and were modified where appropriate based on gradation and index property testing.
- Fine grained soils that plot within the hatched area on the Plasticity Chart, and coarse grained soils with more than half of material larger than the #4 sieve are modified where appropriate.
- If sampler is not able to be driven at least 6 inches then 50/X indicates number of blows required to drive the identified sampler X inches with a 140 pound hammer falling 30 inches.
- TCP - Texas Cone Penetrometer: A 3 inch diameter by 2.5 inch long 60 degree conical point driven with a 140 pound hammer dropped 30 inches.

**FID** - Photoionization Detector

## Unified Soil Classification System (ASTM D 2487)

### Clean Sands

| Cu<sub>6</sub> and Cu<sub>1Cc</sub><sub>3</sub> | GW | Well-Graded Gravels, Gravel-Sand Mixtures with Little or No Fines |
| Cu<sub>4</sub> and Cu<sub>1Cc</sub><sub>3</sub> | GP | Poorly Graded Gravels, Gravel-Sand Mixtures with Little or No Fines |

### Gravels

| Cu<sub>4</sub> and Cu<sub>1Cc</sub><sub>3</sub> | GW-GM | Well-Graded Gravels, Gravel-Sand Mixtures with Little Fines |
| Cu<sub>4</sub> and Cu<sub>1Cc</sub><sub>3</sub> | GW-GC | Well-Graded Gravels, Gravel-Sand Mixtures with Little Clay Fines |
| Cu<sub>4</sub> and Cu<sub>1Cc</sub><sub>3</sub> | GP-GM | Poorly Graded Gravels, Gravel-Sand Mixtures with Little Fines |
| Cu<sub>4</sub> and Cu<sub>1Cc</sub><sub>3</sub> | GP-GC | Poorly Graded Gravels, Gravel-Sand Mixtures with Little Clay Fines |

### Silts and Clays (More than half of material is smaller than the #200 sieve)

| Cu<sub>4</sub> and Cu<sub>1Cc</sub><sub>3</sub> | GM | Silty Gravels, Gravel-Silt-Sand Mixtures |
| Cu<sub>4</sub> and Cu<sub>1Cc</sub><sub>3</sub> | GC | Clayey Gravels, Gravel-Sand-Clay Mixtures |
| Cu<sub>4</sub> and Cu<sub>1Cc</sub><sub>3</sub> | GC-GM | Clayey Gravels, Gravel-Sand-Clay Mixtures |

### Sands (More than half of coarse fraction is larger than the #4 sieve)

| Cu<sub>6</sub> and Cu<sub>1Cc</sub><sub>3</sub> | SW | Well-Graded Sands, Sand-Gravel Mixtures with Little or No Fines |
| Cu<sub>6</sub> and Cu<sub>1Cc</sub><sub>3</sub> | SP | Poorly Graded Sands, Sand-Gravel Mixtures with Little or No Fines |
| Cu<sub>6</sub> and Cu<sub>1Cc</sub><sub>3</sub> | SW-SC | Well-Graded Sands, Sand-Gravel Mixtures with Little Fines |
| Cu<sub>6</sub> and Cu<sub>1Cc</sub><sub>3</sub> | SP-SC | Poorly Graded Sands, Sand-Gravel Mixtures with Little Fines |

### Coarse Grained Soils

| Cu<sub>6</sub> and Cu<sub>1Cc</sub><sub>3</sub> | ML | Inorganic Silts and Very Fine Sands, Silty or Clayey Fine Sands, Silts with Slight Plasticity |
| Cu<sub>6</sub> and Cu<sub>1Cc</sub><sub>3</sub> | CL | Inorganic Clays of Low to Medium Plasticity, Gravelly Clays, Sandy Clays, Silty Clays, Lean Clays |
| Cu<sub>6</sub> and Cu<sub>1Cc</sub><sub>3</sub> | OL | Organic Silts & Organic Silty Clays of Low Plasticity |
| Cu<sub>6</sub> and Cu<sub>1Cc</sub><sub>3</sub> | MH | Inorganic Silts, Micaeous or Diatomaceous Fine Sand or Silt |
| Cu<sub>6</sub> and Cu<sub>1Cc</sub><sub>3</sub> | CH | Inorganic Clays of High Plasticity, Fat Clays |
| Cu<sub>6</sub> and Cu<sub>1Cc</sub><sub>3</sub> | OH | Organic Clays & Organic Silts of Medium to High Plasticity |
### Grain Size

**Description** | **Sieve Size** | **Grain Size** | **Approximate Size**
--- | --- | --- | ---
Boulders | >12 in. (304.8 mm.) | >12 in. (304.8 mm.) | Larger than basketball-sized
Cobbles | 3 - 12 in. (76.2 - 304.8 mm.) | 3 - 12 in. (76.2 - 304.8 mm.) | Fist-sized to basketball-sized
Gravel | coarse | 3/4 - 3 in. (19 - 76.2 mm.) | Thumb-sized to fist-sized
| fine | #4 - 3/4 in. (#4 - 19 mm.) | 0.19 - 0.75 in. (4.8 - 19 mm.) | Pea-sized to thumb-sized
Sand | coarse | #10 - #4 | 0.079 - 0.19 in. (2 - 4.9 mm.) | Rock salt-sized to pea-sized
| medium | #40 - #10 | 0.017 - 0.079 in. (0.43 - 2 mm.) | Sugar-sized to rock salt-sized
| fine | #200 - #40 | 0.0029 - 0.017 in. (0.07 - 0.43 mm.) | Flour-sized to sugar-sized
Fines | Passing #200 | <0.0029 in. (<0.07 mm.) | Flour-sized and smaller

### Secondary Constituent

**Term of Use** | **Secondary Constituent is Fine Grained** | **Secondary Constituent is Coarse Grained**
--- | --- | ---
Trace | <5% | <15%
With | 2 to <15% | 2 to <15%
Modifier | ≥ 15% | ≥ 30%

### Consistency - Fine-Grained Soil

| Consistency | SPT-N60 | Pocket Pen | Unconfined Compressive Strength (Q/psf) | Visual / Manual Criteria |
--- | --- | --- | --- | ---
Very Soft | <2 | PP < 0.25 | <500 | Thumb will penetrate more than 1 inch (25 mm). Extends between fingers when squeezed.
Soft | 2 - 4 | 0.25 < PP < 0.5 | 500 - 1000 | Thumb will penetrate soil about 1 inch (25 mm). Remolded by light finger pressure.
Medium Stiff | 4 - 8 | 0.5 < PP < 1 | 1000 - 2000 | Thumb will penetrate soil about 1/4 inch (6 mm). Remolded by strong finger pressure.
Stiff | 8 - 15 | 1 < PP < 2 | 2000 - 4000 | Can be imprinted with considerable pressure from thumb.
Very Stiff | 15 - 30 | 2 < PP < 4 | 4000 - 8000 | Thumb will not indent soil but readily indented with thumb.
Hard | >30 | 4 < PP | >8000 | Thumbwill not indent soil.

### Moisture Content

| Description | Field Test |
--- | ---
Dry | Absence of moisture, dusty, dry to the touch
Moist | Damp but no visible water
Wet | Visible free water, usually soil is below water table

### Cememtation

| Description | Field Test |
--- | ---
Weakly | Crumbles or breaks with handling or slight finger pressure
Moderately | Crumbles or breaks with considerable finger pressure
Strongly | Will not crumble or break with finger pressure

### Reaction With Hydrochloric Acid

| Description | Field Test |
--- | ---
None | No visible reaction
Weak | Some reaction, with bubbles forming slowly
Strong | Violent reaction, with bubbles forming immediately

### Apparent / Relative Density - Coarse-Grained Soil

| Apparent Density | SPT-N60 (blows/ft) | Modified CA Sampler (blows/ft) | California Sampler (blows/ft) | Relative Density (%) |
--- | --- | --- | --- | ---
Very Loose | <4 | <4 | <5 | 0 - 15
Loose | 4 - 10 | 5 - 12 | 5 - 15 | 15 - 35
Medium Dense | 10 - 30 | 12 - 35 | 15 - 40 | 35 - 65
Dense | 30 - 50 | 35 - 60 | 40 - 70 | 65 - 85
Very Dense | >50 | >60 | >70 | 85 - 100

### Structure

| Description | Criteria |
--- | ---
Stratified | Alternating layers of varying material or color with layers at least 1/4-in. thick, note thickness.
Laminated | Alternating layers of varying material or color with the layer less than 1/4-in. thick, note thickness.
Fissured | Breaks along definite planes of fracture with little resistance to fracturing.
Slicksided | Fracture planes appear polished or glossy, sometimes striated.
Blocky | Cohesive soil that can be broken down into small angular lumps which resist further breakdown.
Lensed | Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness.

### Soil Properties

- **PLASTICITY**
  - **Description** | **LL** | **Field Test**
  - Non-plastic | NP | The thread cannot be rolled at any water content.
  - Low (L) | < 30 | The thread can barely be rolled and the lump or thread cannot be formed when drier than the plastic limit.
  - Medium (M) | 30 - 50 | The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The thread or thread crumbles when drier than the plastic limit.
  - High (H) | > 50 | It takes considerable time rolling and breaking to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump or thread can be formed without crumbling when drier than the plastic limit.

- **ANGULARITY**
  - **Description** | **Criteria**
  - Angular | Particles have sharp edges and relatively plane sides with unpolished surfaces.
  - Subangular | Particles are similar to angular description but have rounded edges.
  - Subrounded | Particles have nearly plane sides but have well-rounded corners and edges.
  - Rounded | Particles have smoothly curved sides and no edges.

### Soil Description Key

- **FROM TERZAGHI AND PECK, 1948; LAMBE AND WHITMAN, 1969; FHWA, 2002; AND ASTM D2488**

- **FROM TERZAGHI AND PECK, 1948**

- **PROPOSED AIRPORT LIFT STATION AT NORTHSIDE WASTEWATER TREATMENT PLANT 5628 NORTH 105TH EAST AVENUE TULSA, OKLAHOMA**

- **FIGURE A-3**
**Infilling Type**

<table>
<thead>
<tr>
<th>Name</th>
<th>Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moderately Weathered</td>
<td>Mw</td>
</tr>
<tr>
<td>Slightly Weathered</td>
<td>Sw</td>
</tr>
<tr>
<td>Intensely Fractured</td>
<td>If</td>
</tr>
<tr>
<td>Vesicle (Vesicular)</td>
<td>V</td>
</tr>
<tr>
<td>Slightly Fractured</td>
<td>SiF</td>
</tr>
<tr>
<td>Manganese</td>
<td>Mn</td>
</tr>
<tr>
<td>Iron Oxide</td>
<td>OX</td>
</tr>
</tbody>
</table>

**Relative Hardness / Strength Descriptions**

<table>
<thead>
<tr>
<th>Grade</th>
<th>UCS (Mpa)</th>
<th>Field Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>R0 Extremely Weak</td>
<td>0.25 - 1.0</td>
<td>Indented by thumbnail</td>
</tr>
<tr>
<td>R1 Very Weak</td>
<td>1.0 - 5.0</td>
<td>Crumbles under firm blows of geological hammer, can be peeled by a pocket knife</td>
</tr>
<tr>
<td>R2 Weak</td>
<td>5.0 - 25</td>
<td>Can be peeled by a pocket knife with difficulty, shallow indentations made by firm blow with point of geological hammer</td>
</tr>
<tr>
<td>R3 Medium Strong</td>
<td>25 - 50</td>
<td>Cannot be scraped or peeled with a pocket knife, specimen can be fractured with a single firm blow of a geological hammer</td>
</tr>
<tr>
<td>R4 Strong</td>
<td>50 - 100</td>
<td>Specimen requires more than one blow of geological hammer to fracture it</td>
</tr>
<tr>
<td>R5 Very Strong</td>
<td>100 - 250</td>
<td>Specimen requires many blows of geological hammer to fracture it</td>
</tr>
<tr>
<td>R6 Extremely Strong</td>
<td>&gt; 250</td>
<td>Specimen can only be chipped with a geological hammer</td>
</tr>
</tbody>
</table>

**Rock Quality Designation (RQD)**

<table>
<thead>
<tr>
<th>Description</th>
<th>RQD (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Poor</td>
<td>0 - 25</td>
</tr>
<tr>
<td>Poor</td>
<td>25 - 50</td>
</tr>
<tr>
<td>Fair</td>
<td>50 - 75</td>
</tr>
<tr>
<td>Good</td>
<td>75 - 90</td>
</tr>
<tr>
<td>Excellent</td>
<td>90 - 100</td>
</tr>
</tbody>
</table>

**Aperture**

<table>
<thead>
<tr>
<th>Description</th>
<th>Criteria [in (mm)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tight</td>
<td>&lt;0.04 (&lt;1)</td>
</tr>
<tr>
<td>Open</td>
<td>0.04 - 0.20 (1 - 5)</td>
</tr>
<tr>
<td>Wide</td>
<td>&gt;0.20 (&gt;5)</td>
</tr>
</tbody>
</table>

**Bedding Characteristics**

<table>
<thead>
<tr>
<th>Description</th>
<th>Thickness [in (mm)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Thick Bedded</td>
<td>&gt;36 (&gt;915)</td>
</tr>
<tr>
<td>Thick Bedded</td>
<td>12 - 36 (305 - 915)</td>
</tr>
<tr>
<td>Moderately Bedded</td>
<td>4 - 12 (102 - 305)</td>
</tr>
<tr>
<td>Thin Bedded</td>
<td>1 - 4 (25 - 102)</td>
</tr>
<tr>
<td>Very Thin Bedded</td>
<td>0.4 - 1 (10 - 25)</td>
</tr>
<tr>
<td>Laminated</td>
<td>0.1 - 0.4 (2.5 - 10)</td>
</tr>
<tr>
<td>Thiny Laminated</td>
<td>&lt;0.1 (&lt;2.5)</td>
</tr>
</tbody>
</table>

**Joint Roughness Coefficient (JRC)**

<table>
<thead>
<tr>
<th>RQD</th>
<th>JRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 2</td>
<td>0</td>
</tr>
<tr>
<td>2 - 4</td>
<td>2</td>
</tr>
<tr>
<td>4 - 6</td>
<td>6</td>
</tr>
<tr>
<td>6 - 8</td>
<td>8</td>
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<tr>
<td>8 - 10</td>
<td>10</td>
</tr>
<tr>
<td>10 - 12</td>
<td>12</td>
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<td>12 - 14</td>
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<tr>
<td>14 - 16</td>
<td>16</td>
</tr>
<tr>
<td>16 - 18</td>
<td>18</td>
</tr>
<tr>
<td>&gt;18</td>
<td>20</td>
</tr>
</tbody>
</table>

**Additional Textural Adjectives**

- Pit (Pitted): Pithole to 0.03 ft. (3.8 in.) (>1 to 10 mm) openings
- Vug (Vuggy): Small openings (usually lined with crystals) ranging in diameter from 0.03 ft. (3.8 in.) to 0.33 ft. (4 in.) (10 to 100 mm)
- Cavity: An opening larger than 0.33 ft. (4 in.) (100 mm), size descriptions are required, and adjectives such as small, large, etc., may be used
- Honeycombed: If numerous enough that only thin walls separate individual pits or vugs, this term further describes the preceding nomenclature to indicate cell-like form.
- Vesicle (Vesicular): Small openings in volcanic rocks of variable shape and size formed by entrapped gas bubbles during solidification.

**Core Sampler Type Graphics**

- EX CORE BARREL (0.846 in. (21.5 mm.) core diameter)
- HQ CORE SAMPLE (2.500 in. (63.5 mm.) core diameter)
- AQ CORE BARREL (1.067 in. (27.1 mm.) core diameter)
- AX CORE BARREL (1.185 in. (30.1 mm.) core diameter)
- NO CORE SAMPLE (1.874 in. (47.6 mm.) core diameter)
- NO RECOVERY CORE SAMPLE
- BX CORE BARREL (1.433 in. (36.4 mm.) core diameter)
- CONTINUOUS CORE SAMPLE (2.000 in. (50.8 mm.) core diameter)
The boring was terminated because of practical auger refusal (*) at approximately 28.5 ft. below ground surface on bedrock. The boring was backfilled with auger cuttings and bentonite on October 17, 2018.

Groundwater was observed at approximately 18.5 ft. below ground surface during drilling.

GENERAL NOTES:
The exploration location and elevation are approximate and were estimated by Kleinfelder.
An iPad integrated GPS unit was used to locate the exploration with an accuracy of 15 feet.
TOPSOIL

Fat CLAY (CH): medium plasticity, dark gray, moist, very stiff to medium

Lean CLAY (CL): low plasticity, dark gray, moist, medium stiff to soft

LIMESTONE

The boring was terminated because of practical auger refusal at approximately 30 ft. below ground surface on bedrock. The boring was backfilled with auger cuttings and bentonite on October 17, 2018.

GROUNDWATER LEVEL INFORMATION:
- Groundwater was observed at approximately 10 ft. below ground surface 1 hour after drilling completion.
- Groundwater was observed at approximately 18.5 ft. below ground surface during drilling.

GENERAL NOTES:
The exploration location and elevation are approximate and were estimated by Kleinfelder.
An iPad integrated GPS unit was used to locate the exploration with an accuracy of 15 feet.
APPENDIX B

LABORATORY TESTING PROGRAM
APPENDIX B
LABORATORY TESTING PROGRAM

GENERAL

Laboratory tests were performed on select, representative samples to evaluate pertinent engineering properties of these materials. We directed our laboratory testing program primarily toward classifying the subsurface materials and measuring index values of the on-site materials. Laboratory tests were performed in general accordance with applicable standards. The results of the laboratory tests are presented on the respective boring logs. The laboratory testing program consisted of the following:

- **Moisture content tests**, ASTM D2216, Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
- **Particle size analysis of soil**, ASTM D422, Standard Test Methods for Particle-Size Analysis of Soils
- **Sulfate Test**, EPA Method 300.0: Determination of Inorganic Anions by Ion Chromatography
- **pH Lab Test**, EPA Method 9045D: Soil and Waste pH, part of Test Methods for Evaluating Solid Waste, Physical/Chemical Methods
- **Chloride Test**, EPA Method 300.0: Determination of Inorganic Anions by Ion Chromatography
<table>
<thead>
<tr>
<th>Exploration ID</th>
<th>Depth (ft.)</th>
<th>Sample No.</th>
<th>Sample Description</th>
<th>USCS</th>
<th>AASHTO</th>
<th>Water Content (%)</th>
<th>Plastic Limits</th>
<th>Plasticity Index</th>
<th>Atterberg Limits</th>
<th>Sieve Analysis (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-1</td>
<td>0.5 - 2.0</td>
<td>SS-1</td>
<td>FAT CLAY</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.5 - 5.0</td>
<td>SS-2</td>
<td></td>
<td>CH</td>
<td>A-7-6</td>
<td>14.2</td>
<td>23.0</td>
<td>23</td>
<td>29</td>
<td>99</td>
</tr>
<tr>
<td>B-1</td>
<td>8.5 - 10.0</td>
<td>SS-4</td>
<td>LEAN CLAY</td>
<td>CL</td>
<td>A-7-6</td>
<td></td>
<td>23.2</td>
<td>41</td>
<td>18</td>
<td>23</td>
</tr>
<tr>
<td>B-1</td>
<td>18.5 - 20.0</td>
<td>SS-6</td>
<td>LEAN CLAY WITH SAND</td>
<td>CL</td>
<td>A-6</td>
<td></td>
<td>26.7</td>
<td>26</td>
<td>15</td>
<td>11</td>
</tr>
<tr>
<td>B-2</td>
<td>3.5 - 5.0</td>
<td>SS-2</td>
<td>FAT CLAY</td>
<td>CH</td>
<td>A-7-6</td>
<td></td>
<td>23.4</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>B-2</td>
<td>5.0 - 7.0</td>
<td>ST-3</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>B-2</td>
<td>8.5 - 10.0</td>
<td>SS-4</td>
<td>LEAN CLAY</td>
<td>CL</td>
<td>A-6</td>
<td></td>
<td>22.1</td>
<td>35</td>
<td>16</td>
<td>19</td>
</tr>
<tr>
<td>B-2</td>
<td>18.5 - 20.0</td>
<td>SS-7</td>
<td>LEAN CLAY WITH SAND</td>
<td>CL</td>
<td>A-6</td>
<td></td>
<td>25.9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B-2</td>
<td>23.5 - 25.0</td>
<td>SS-8</td>
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</tbody>
</table>

Refer to the Geotechnical Evaluation Report or the supplemental plates for the method used for the testing performed above.
NP = Nonplastic
NA = Not Available
### ONE-DIMENSIONAL SWELL REPORT ASTM D4546

**DATE** 10/29/2018  
**Project:** Northside WWTP Lift Station  
**Project No.:** 20192112  
**Boring No.:** B-1  
**Sample No.:** ST-3  
**Sample Depth:** 5.0-7.0 Ft

**Soil Description:** Fat Clay, dark brown

| Sample Diameter: | 2.500 inches |
| Sample Height: | 0.749 inches |
| Surcharge Pressure: | 0 psf |

<table>
<thead>
<tr>
<th></th>
<th>Before Test</th>
<th>After Test</th>
<th>Atterberg Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Content (%)</td>
<td>21.3</td>
<td>24.3</td>
<td>Liquid Limit</td>
</tr>
<tr>
<td>Dry Density (pcf)</td>
<td>103.9</td>
<td>98.8</td>
<td>Plastic Limit</td>
</tr>
<tr>
<td>Void Ratio (-)</td>
<td>0.6</td>
<td>0.7</td>
<td>Plasticity Index</td>
</tr>
</tbody>
</table>

**One-Dimensional Swell @ Surcharge Pressure:** 4.81 %

![Graph showing One-Dimensional Swell over Time](image)
UNCONFINED COMPRESSION TEST REPORT
ASTM D-2166

Project: Airport Lift Station NSWTP
Project No.: 20192112
Date Tested: 10/22/2018
Tested By: CG
Boring No.: B-2
Sample No.: ST-3
Sample Depth: 5.0-7.0 feet
Sample Description: Lean Clay, brown

Atterberg Limits: LL= N/A
PL= N/A
PI= N/A
Percentage of Fines: N/A
USCS Classification: CL

Sample Type: Shelby Tube
Moisture Content(%): 24.2
Initial Diameter (inches): 2.820
Wet Density (pcf): 125
Initial Height (inches): 5.576
Dry Density (pcf): 101
Height-Diameter Ratio: 2.0
Specific Gravity (assumed): 2.7
Saturation (%): 97

Unconfined Strength, PSF: 5562
Unconfined Strength, PSI: 38.6
Sample Project Name: 20192112
Date Samples Received: October 23, 2018  Time: 10:26  sample temp upon arrival at lab = 22°C
Matrix: Solid
Lab Log Numbers: AJ23032-01 AJ23032-02
Work Order: AJ23032
Report #: AJ23032-1030181027
EPA Lab ID#'s: Stillwater OK00092  Tulsa OK00983  OKC OK00129  ICR OK 001
Oklahoma Certification: Stillwater WasteWater, DEQ 8316/ Drinking Water, DEQ D9602
Tulsa WasteWater, DEQ 9905 / Drinking Water, DEQ D9901
Oklahoma City WasteWater DEQ 7202 / Drinking Water, DEQ D9937
Kansas Certification: Stillwater NELAP CERT # E-10219
Oklahoma City NELAP CERT # E-10414
New Hampshire Cert.: Oklahoma City Drinking Water NH ELAP Lab ID # 2072
Texas Certification: Stillwater Drinking Water NELAP CERT # T105704533-14-1
Analysis Reference: If qualifiers present in "Prep Info" or "Analysis Info", then analysis performed as follows: @= Tulsa Lab and * = OKC Lab. If no qualifiers present, then analysis performed at Stillwater Lab.
Accurate Environmental Laboratories certify that the test results performed at the Stillwater lab meet all requirements of NELAP. Any exceptions to this can be found in the report footer or Quality Control Section of the report.
This report is to only be replicated in its entirety.
Accurate Environmental sampling protocol was followed for any sampling performed by Accurate Field Services.
### Sample: B-1 st-7

**Collection Type:** Grab  
**Sample Time:** 10/17/18 0:00  
**Lab Log#:** AJ23032-01

<table>
<thead>
<tr>
<th>Method/Parameter</th>
<th>Test</th>
<th>Result</th>
<th>Notes</th>
<th>PQL#</th>
<th>Prep Info</th>
<th>Analysis Info</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloride</td>
<td>EPA 300.0</td>
<td>Chloride</td>
<td>41.6 mg/kg dry</td>
<td>5.00</td>
<td>10/24/18 12:23 BM</td>
<td>10/24/18 22:51 BM</td>
</tr>
<tr>
<td>pH in Lab</td>
<td>EPA 9045D</td>
<td>pH</td>
<td>7.47 pH Units</td>
<td>0.0100</td>
<td>10/26/18 11:12 ZS</td>
<td>10/26/18 11:17 ZS</td>
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<tr>
<td>Sulfate</td>
<td>EPA 300.0</td>
<td>Sulfate</td>
<td>31.5 mg/kg dry</td>
<td>5.00</td>
<td>10/24/18 12:23 BM</td>
<td>10/24/18 22:51 BM</td>
</tr>
<tr>
<td>Solids, Percent</td>
<td>SM2540 B</td>
<td>Percent Solids</td>
<td>77.29 %</td>
<td>0.100</td>
<td>10/24/18 10:33 ZS</td>
<td>10/25/18 11:32 TM</td>
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### Sample: B-2 st-6

**Collection Type:** Grab  
**Sample Time:** 10/17/18 0:00  
**Lab Log#:** AJ23032-02

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<tr>
<th>Method/Parameter</th>
<th>Test</th>
<th>Result</th>
<th>Notes</th>
<th>PQL#</th>
<th>Prep Info</th>
<th>Analysis Info</th>
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</thead>
<tbody>
<tr>
<td>Chloride</td>
<td>EPA 300.0</td>
<td>Chloride</td>
<td>33.1 mg/kg dry</td>
<td>5.00</td>
<td>10/24/18 12:23 BM</td>
<td>10/25/18 01:06 BM</td>
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<tr>
<td>pH in Lab</td>
<td>EPA 9045D</td>
<td>pH</td>
<td>7.18 pH Units</td>
<td>0.0100</td>
<td>10/26/18 11:12 ZS</td>
<td>10/26/18 11:17 ZS</td>
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<tr>
<td>Sulfate</td>
<td>EPA 300.0</td>
<td>Sulfate</td>
<td>27.5 mg/kg dry</td>
<td>5.00</td>
<td>10/24/18 12:23 BM</td>
<td>10/25/18 01:06 BM</td>
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<tr>
<td>Solids, Percent</td>
<td>SM2540 B</td>
<td>Percent Solids</td>
<td>78.29 %</td>
<td>0.100</td>
<td>10/24/18 10:33 ZS</td>
<td>10/25/18 11:32 TM</td>
</tr>
</tbody>
</table>

**Notes and Definitions**

- **MCL**: Analyte concentration may exceed Maximum Contaminant Limit (MCL) for EPA Primary or Secondary Drinking Water Regulations.
- **###**: Analyte concentration may exceed regulatory limit.
- **PQL**: Practical Quantitation Limit - the method reporting limit (MRL) adjusted for any dilutions or other changes made to the sample to deal with interferences/matrix effects.
- **BPQL**: Below Practical Quantitation Limit (if applicable).

The "Prep Date" of the QC analysis coincides with the characters of the appropriate QC Lab ID. (Example: 19 A 02 15 - BLK = 2019, Jan 2, Batch #15 - Blank)

**Lab Manager**

![Signature]
### Quality Control Data

#### Blank Data

<table>
<thead>
<tr>
<th>QC Lab #</th>
<th>Test Group</th>
<th>Test</th>
<th>Result</th>
<th>PQL</th>
<th>Flags</th>
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<td>18J2449-BLK1</td>
<td>Chloride</td>
<td>BPQL</td>
<td>mg/kg</td>
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<tr>
<td>18J2449-BLK1</td>
<td>Sulfate</td>
<td>BPQL</td>
<td>mg/kg</td>
<td>5.00</td>
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#### Duplicate Sample Data

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<tr>
<th>QC Lab #</th>
<th>Test Group</th>
<th>Test Name</th>
<th>Source</th>
<th>Dup Result</th>
<th>Samp Result</th>
<th>% RPD</th>
<th>RPD Limit</th>
<th>Flags</th>
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<tbody>
<tr>
<td>18J2449-DUP1</td>
<td>Chloride</td>
<td>Chloride</td>
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<td>41.3</td>
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<td>pH</td>
<td>AJ23032-02</td>
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<td>7.18</td>
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<td>18J2449-DUP1</td>
<td>Sulfate</td>
<td>Sulfate</td>
<td>AJ23032-01</td>
<td>31.0</td>
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#### Laboratory Control Sample Data

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<th>Test Name</th>
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<th>Units</th>
<th>% Rec.</th>
<th>Control Limits</th>
<th>Flags</th>
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<tbody>
<tr>
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<td>Chloride</td>
<td>Chloride</td>
<td>29.4</td>
<td>30.00</td>
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<td>7.05</td>
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#### Matrix Spike Data

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<th>Test Name</th>
<th>Source Sample</th>
<th>Sample Result</th>
<th>Units</th>
<th>Spike Result</th>
<th>Spike Level</th>
<th>% Rec.</th>
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<td>AJ23032-01</td>
<td>41.6</td>
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<td>99</td>
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<tr>
<td>18J2449-MS1</td>
<td>Sulfate</td>
<td>Sulfate</td>
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<td>31.5</td>
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<td>72.6</td>
<td>43.14</td>
<td>95</td>
<td>80 - 120</td>
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</table>
APPENDIX C

GBA DOCUMENT
The GeoProfessional Business Association (GBA) has prepared this advisory to help you — presumably a client representative — interpret and apply this geotechnical-engineering report as effectively as possible. In that way, clients can benefit from a lowered exposure to the subsurface problems that, for decades, have been a principal cause of construction delays, cost overruns, claims, and disputes. If you have questions or want more information about any of the issues discussed below, contact your GBA-member geotechnical engineer. Active involvement in the GeoProfessional Business Association exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project.

Geotechnical-Engineering Services Are Performed for Specific Purposes, Persons, and Projects
Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical-engineering study conducted for a given civil engineer will not likely meet the needs of a civil-works constructor or even a different civil engineer. Because each geotechnical-engineering study is unique, each geotechnical-engineering report is unique, prepared solely for the client. Those who rely on a geotechnical-engineering report prepared for a different client can be seriously misled. No one except authorized client representatives should rely on this geotechnical-engineering report without first conferring with the geotechnical engineer who prepared it. And no one – not even you – should apply this report for any purpose or project except the one originally contemplated.

Read this Report in Full
Costly problems have occurred because those relying on a geotechnical-engineering report did not read it in its entirety. Do not rely on an executive summary. Do not read selected elements only. Read this report in full.

You Need to Inform Your Geotechnical Engineer about Change
Your geotechnical engineer considered unique, project-specific factors when designing the study behind this report and developing the confirmation-dependent recommendations the report conveys. A few typical factors include:
- the client's goals, objectives, budget, schedule, and risk-management preferences;
- the general nature of the structure involved, its size, configuration, and performance criteria;
- the structure's location and orientation on the site; and
- other planned or existing site improvements, such as retaining walls, access roads, parking lots, and underground utilities.

Typical changes that could erode the reliability of this report include those that affect:
- the site's size or shape;
- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light-industrial plant to a refrigerated warehouse;
- the elevation, configuration, location, orientation, or weight of the proposed structure;
- the composition of the design team; or
- project ownership.

As a general rule, always inform your geotechnical engineer of project changes — even minor ones — and request an assessment of their impact. The geotechnical engineer who prepared this report cannot accept responsibility or liability for problems that arise because the geotechnical engineer was not informed about developments the engineer otherwise would have considered.

This Report May Not Be Reliable
Do not rely on this report if your geotechnical engineer prepared it:
- for a different client;
- for a different project;
- for a different site (that may or may not include all or a portion of the original site); or
- before important events occurred at the site or adjacent to it; e.g., man-made events like construction or environmental remediation, or natural events like floods, droughts, earthquakes, or groundwater fluctuations.

Note, too, that it could be unwise to rely on a geotechnical-engineering report whose reliability may have been affected by the passage of time, because of factors like changed subsurface conditions; new or modified codes, standards, or regulations; or new techniques or tools. If your geotechnical engineer has not indicated an “apply-by” date on the report, ask what it should be, and, in general, if you are the least bit uncertain about the continued reliability of this report, contact your geotechnical engineer before applying it. A minor amount of additional testing or analysis — if any is required at all — could prevent major problems.

Most of the “Findings” Related in This Report Are Professional Opinions
Before construction begins, geotechnical engineers explore a site's subsurface through various sampling and testing procedures. Geotechnical engineers can observe actual subsurface conditions only at those specific locations where sampling and testing were performed. The data derived from that sampling and testing were reviewed by your geotechnical engineer, who then applied professional judgment to form opinions about subsurface conditions throughout the site. Actual sitewide-subsurface conditions may differ — maybe significantly — from those indicated in this report. Confront that risk by retaining your geotechnical engineer to serve on the design team from project start to project finish, so the individual can provide informed guidance quickly, whenever needed.
This Report’s Recommendations Are Confirmation-Dependent

The recommendations included in this report – including any options or alternatives – are confirmation-dependent. In other words, they are not final, because the geotechnical engineer who developed them relied heavily on judgment and opinion to do so. Your geotechnical engineer can finalize the recommendations only after observing actual subsurface conditions revealed during construction. If through observation your geotechnical engineer confirms that the conditions assumed to exist actually do exist, the recommendations can be relied upon, assuming no other changes have occurred. The geotechnical engineer who prepared this report cannot assume responsibility or liability for confirmation-dependent recommendations if you fail to retain that engineer to perform construction observation.

This Report Could Be Misinterpreted

Other design professionals’ misinterpretation of geotechnical-engineering reports has resulted in costly problems. Confront that risk by having your geotechnical engineer serve as a full-time member of the design team, to:

• confer with other design-team members,
• help develop specifications,
• review pertinent elements of other design professionals’ plans and specifications, and
• be on hand quickly whenever geotechnical-engineering guidance is needed.

You should also confront the risk of constructors misinterpreting this report. Do so by retaining your geotechnical engineer to participate in prebid and preconstruction conferences and to perform construction observation.

Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can shift unanticipated-subsurface-conditions liability to constructors by limiting the information they provide for bid preparation. To help prevent the costly, contentious problems this practice has caused, include the complete geotechnical-engineering report, along with any attachments or appendices, with your contract documents, but be certain to note conspicuously that you’ve included the material for informational purposes only. To avoid misunderstanding, you may also want to note that “informational purposes” means constructors have no right to rely on the interpretations, opinions, conclusions, or recommendations in the report, but they may rely on the factual data relative to the specific times, locations, and depths/elevations referenced. Be certain that constructors know they may learn about specific project requirements, including options selected from the report, only from the design drawings and specifications. Remind constructors that they may perform their own studies if they want to, and be sure to allow enough time to permit them to do so. Only then might you be in a position to give constructors the information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions. Conducting prebid and preconstruction conferences can also be valuable in this respect.

Read Responsibility Provisions Closely

Some client representatives, design professionals, and constructors do not realize that geotechnical engineering is far less exact than other engineering disciplines. That lack of understanding has nurtured unrealistic expectations that have resulted in disappointments, delays, cost overruns, claims, and disputes. To confront that risk, geotechnical engineers commonly include explanatory provisions in their reports. Sometimes labeled “limitations,” many of these provisions indicate where geotechnical engineers’ responsibilities begin and end, to help others recognize their own responsibilities and risks. Read these provisions closely. Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The personnel, equipment, and techniques used to perform an environmental study – e.g., a “phase-one” or “phase-two” environmental site assessment – differ significantly from those used to perform a geotechnical-engineering study. For that reason, a geotechnical-engineering report does not usually relate any environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. Unanticipated subsurface environmental problems have led to project failures. If you have not yet obtained your own environmental information, ask your geotechnical consultant for risk-management guidance. As a general rule, do not rely on an environmental report prepared for a different client, site, or project, or that is more than six months old.

Obtain Professional Assistance to Deal with Moisture Infiltration and Mold

While your geotechnical engineer may have addressed groundwater, water infiltration, or similar issues in this report, none of the engineer’s services were designed, conducted, or intended to prevent uncontrolled migration of moisture – including water vapor – from the soil through building slabs and walls and into the building interior, where it can cause mold growth and material-performance deficiencies. Accordingly, proper implementation of the geotechnical engineer’s recommendations will not of itself be sufficient to prevent moisture infiltration. Confront the risk of moisture infiltration by including building-envelope or mold specialists on the design team. Geotechnical engineers are not building-envelope or mold specialists.