

CONTRACT DOCUMENTS AND SPECIFICATIONS
FOR
RAW WATER STATION GENERATOR AND MCC UPGRADES
FOR THE
CITY OF GEORGETOWN
PROJECT # 1607

HOWARD ENGINEERING PROJECT NO. A23121

APRIL 2024

Contractor: _____

Address: _____

Contractor's License Number: _____



Howard Engineering, Inc.
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**CONTRACT DOCUMENTS AND SPECIFICATIONS
FOR
RAW WATER STATION GENERATOR AND MCC UPGRADES
FOR THE
CITY OF GEORGETOWN**

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APRIL 2024

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MARCH 2024

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SECTION 01010

SUMMARY OF WORK

PART 1 - GENERAL

1.1 DESCRIPTION

- A. The Work to be done under these Contracts and in accordance with these Specifications consists of furnishing all equipment, superintendence, labor, skill, material and all other items necessary for the City of Georgetown Raw Water Pump Station Generator and MCC Upgrades.

The Contractor shall perform all work required for such construction in accordance with the Contract Documents and subject to the terms and conditions of the Contract, complete and ready for use.

- B. The work generally consists of the following items:
1. Demolition and renovation of the existing electrical building.
 2. Replacement of existing MCC and electrical system with new main breaker, ATS, panelboards and VFDs.
 3. Replacement of existing indoor generator with new generator with weatherproof enclosure.
 4. Replacement of all conduits and wiring.
 5. Installation of new RTUs and Alarm Panel to provide control and monitoring of new systems.
- C. The foregoing description shall be construed as a complete description of all work required.

1.2 CONTRACT DOCUMENTS

- A. The Work to be done is shown on the set of Drawings entitled "Raw Water Station Generator and MCC Upgrades" dated April, 2024. The numbers and titles of all Drawings appear on the cover sheet of the Drawings. All drawings so enumerated shall be considered an integral part of the Contract Documents as defined herein.
- B. Where references in the Contract Documents are made to Contractors for specific disciplines of work (i.e. Electrical Contractor, etc.), these references shall be interpreted to be the single prime Contractor when the project is bid or awarded as a single prime contract.

1.3 GENERAL ARRANGEMENT

- A. Drawings indicate the extent and general arrangement of the work. If any departures from the Drawings are deemed necessary by the Contractor to accommodate the materials and equipment he proposes to furnish, details of such departures and reasons therefore shall be submitted as soon as practicable to the Engineer for approval. No such departures shall be made without the prior written approval of the Engineer. Approved changes shall be made without additional cost to the Owner for this work or related work under other Contracts of the Project.
- B. The specific equipment proposed for use by the Contractor on the project may require changes, in structures, auxiliary equipment, piping, electrical, mechanical, controls or other work to provide a complete satisfactory operating installation. The Contractor shall submit to the Engineer, for approval, all necessary Drawings and details showing such changes to verify conformance with the overall project structural and architectural requirements and overall project operating performance. The Bid Price shall include all costs in connection with the preparation of new drawings and details and all changes to construction work to accommodate the proposed equipment, including increases in the costs of other Contracts.

1.4 CONSTRUCTION PERMITS, EASEMENTS AND ENCROACHMENTS

- A. The Contractor shall obtain, keep current and pay all fees for any necessary construction permits from those authorities, agencies, or municipalities having jurisdiction over land areas, utilities, or structures which are located within the Contract limits and which will be occupied, encountered, used, or temporarily interrupted by the Contractor's operations unless otherwise stated. Record copies of all permits shall be furnished to the Engineer.
- B. When construction permits are accompanied by regulations or requirements issued by a particular authority, agency or municipality, it shall be the Contractor's responsibility to familiarize himself and comply with such regulations or requirements as they apply to his operations on this Project.

1.5 TIME OF WORK

- A. The normal time of work for this Contract is limited to 40 hours per week and shall generally be between the hours of 7:00 a.m. and 5:00 p.m., Monday through Friday. The Contractor may elect to work beyond these hours or on weekends provided that all costs incurred by the Owner for additional engineering shall be borne by the Contractor.
- B. If it shall become imperative to perform work at night, the Owner and Engineer shall be informed a reasonable time in advance of the beginning of such work. Temporary lighting and all other necessary facilities for performing and inspecting the work shall be provided and maintained by the Contractor.

1.6 LIMITS OF WORK AREA

- A. The Contractor shall confine his construction operations within the Contract limits shown on the Drawings and/or property lines and/or fence lines. Storage of equipment and materials, or erection and use of sheds outside of the Contract limits, if such areas are the property of the Owner, shall be used only with the Owner's approval. Such storage or temporary structures, even within the Contract's limits, shall be confined to the Owner's property and shall not be placed on properties designated as easements or rights-of-way unless specifically permitted elsewhere in the Contract Documents.

PART 2 - PRODUCTS

(NOT USED)

PART 3 – EXECUTION

(NOT USED)

SECTION 01210

PRECONSTRUCTION CONFERENCE

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Work included: To help clarify construction contract administration procedures, the Engineer will conduct a Preconstruction Conference prior to start of the Work. Provide attendance by the designated personnel.
- B. Related work: Documents affecting work of this Section include, but are not necessarily limited to, General Conditions, Supplementary Conditions, and Sections in Division 1 of these Specifications.

1.2 QUALITY ASSURANCE

- A. For those persons designated by the Contractor, his subcontractors, and suppliers to attend the Preconstruction Conference, provide required authority to commit the entities they represent to solutions agreed upon in the Conference.

1.3 SUBMITTALS

- A. To the maximum extent practicable, advise the Engineer at least 24 hours in advance of the Conference as to items to be added to the agenda.
- B. The Engineer will compile minutes of the Conference, and will furnish three copies of the minutes to the Contractor and required copies to the Owner. The Contractor may make and distribute such other copies as he wishes.

1.4 PRECONSTRUCTION CONFERENCE

- A. The Conference will be scheduled to be held within 30 working days after the Owner has determined the low bidder and may be held prior to issuance of the Notice to Proceed when required by regulatory agencies having jurisdiction. In any event, the Conference will be held prior to actual start of the work.
- B. Attendance:
 - 1. Provide attendance by authorized representatives of the Contractor and major subcontractors.
 - 2. The Engineer will advise other interested parties, including the Owner, and request their attendance.
- C. Minimum agenda: Data will be distributed and discussed on:
 - 1. Organizational arrangement of Contractor's forces and personnel and those of subcontractors, materials suppliers, and the Engineer.
 - 2. Channels and procedures for communication.
 - 3. Construction schedule, including sequence of critical work.
 - 4. Contract Documents, including distribution of required copies of Drawings and revisions.
 - 5. Processing of Shop Drawings and other data submitted to the Engineer for review.
 - 6. Processing of field decisions and Change Orders.
 - 7. Rules and regulations governing performance of the Work.
 - 8. Procedures for security, quality control, housekeeping, and related matters.

PART 2 – PRODUCTS - Not Applicable

PART 3 – EXECUTION - Not Applicable

END OF SECTION

SECTION 01220

PROJECT MEETINGS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Work included: To enable orderly review during progress of the Project, and to provide for systematic discussion of problems, the Engineer will conduct project meetings throughout the construction period.
- B. Related work:
 - 1. Documents affecting work of this Section include, but are not necessarily limited to, General Conditions, Supplementary Conditions, and Sections in Division 1 of these Specifications.
 - 2. The Contractor's relations with his subcontractors and materials suppliers, and discussions relative thereto, are the Contractor's responsibility and normally are not part of project meetings content.

1.2 QUALITY ASSURANCE

- A. For those persons designated by the Contractor to attend and participate in project meetings, provide required authority to commit the Contractor to solutions agreed upon in the project meetings.

1.3 SUBMITTALS

- A. Agenda items: To the maximum extent practicable, advise the Engineer at least 48 hours in advance of project meetings regarding items to be added to the agenda.
- B. Minutes:
 - 1. The Engineer will compile Minutes of each project meeting, and will furnish three copies to the Contractor and required copies to Owner.
 - 2. Recipients of copies may make and distribute such other copies as they wish.

PART 2 - PRODUCTS - Not Applicable

PART 3 - EXECUTION

3.1 MEETING SCHEDULE

- A. Project meetings will be held monthly or as requested by the Engineer.
- B. Coordinate as necessary to establish mutually acceptable schedule for meetings.

3.2 MEETING LOCATION

- A. The Engineer will establish meeting location. To the maximum extent practicable, meetings will be held at the project site.

3.3 PROJECT MEETINGS

- A. Attendance:
 - 1. To the maximum extent practicable, assign the same person or persons to represent the Contractor at project meetings throughout progress of the Work.
 - 2. Subcontractors, materials suppliers, and others may be invited to attend those project meetings in which their aspect of the Work is involved.

- B. Minimum agenda:
 - 1. Review, revise as necessary, and approve Minutes of previous meetings.
 - 2. Review progress of the Work since last meeting, including status of submittals for approval.
 - 3. Identify problems that impede planned progress.
 - 4. Develop corrective measures and procedures to regain planned schedule.
 - 5. Complete other current business.

- C. Revisions to Minutes:
 - 1. Unless published Minutes are challenged in writing prior to the next regularly scheduled progress meeting, they will be accepted as properly stating the activities and decisions of the meeting.
 - 2. Persons challenging published Minutes shall reproduce and distribute copies of the challenge to all Minutes.
 - 3. Challenge to Minutes shall be settled as priority portion of "old business" at the next regularly scheduled meeting.

END OF SECTION

SECTION 01310

CONSTRUCTION SCHEDULES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Work included: To assure adequate planning and execution of the Work so that the Work is completed within the number of calendar days allowed in the Contract, and to assist the Engineer in appraising the reasonableness of the proposed schedule and in evaluating progress of the Work, prepare and maintain the schedules and reports described in this Section.
- B. Related work:
 - 1. Documents affecting work of this Section include, but are not necessarily limited to, General Conditions, Supplementary Conditions, and Sections in Division 1 of these Specifications.
 - 2. Requirements for progress schedule: General Conditions.
 - 3. Construction period: Form of Agreement.
- C. Definitions: "Day", as used throughout the Contract unless otherwise stated, means calendar day.

1.2 QUALITY ASSURANCE

- A. Employ a scheduler who is thoroughly trained and experienced in compiling construction schedule data, and in preparing and issuing periodic reports as required below.
- B. Perform data preparation, analysis, charting, and updating in accordance with standards approved by the Engineer.
- C. Reliance upon the approved schedule:
 - 1. The construction schedule as approved by the Engineer will be an integral part of the Contract and will establish interim completion dates for the various activities under the Contract.
 - 2. Should any activity not be completed within 15 days after the stated scheduled date, the Owner shall have the right to require the Contractor to expedite completion of the activity by whatever means the Owner deems appropriate and necessary, without additional compensation to the Contractor.
 - 3. Should any activity be 30 days or more behind schedule, the Owner shall have the right to perform the activity or have the activity performed by whatever method the Owner deems appropriate.
 - 4. Costs incurred by the Owner and by the Engineer in connection with expediting construction activity shall be reimbursed by the Contractor.
 - 5. It is expressly understood and agreed that failure by the Owner to exercise the option either to order the Contractor to expedite an activity or to expedite the activity by other means shall not be considered to set a precedent for any other activities.

1.3 SUBMITTALS

- A. Comply with pertinent provisions of Section 01340.
- B. Preliminary analysis: Within 10 calendar days after the Contractor has received the Notice to Proceed, submit one reproducible copy and four prints of a preliminary construction schedule prepared in accordance with Part 3 of this Section.

- C. Construction schedule: Within 10 calendar days after the Contractor has received the Engineer's approval to revisions of a preliminary construction schedule, submit one reproducible copy and four prints of a construction schedule prepared in accordance with Part 3 of this Section.
- D. Periodic reports: On the first working day of each month following the submittal described in Paragraph 1.3.C above, submit four prints of the construction schedule updated as described in Part 3 of this Section.

PART 2 - PRODUCTS

2.1 CONSTRUCTION ANALYSIS

- A. Graphically show by bar chart the order and interdependence of all activities necessary to complete the work, and the sequence in which each activity is to be accomplished, as planned by the Contractor and his project field superintendent in coordination with all subcontractors whose work is shown on the diagram.
 - 1. Provide two line bar chart; one for planned activity, and one for actual completion.
- B. Include, but do not necessarily limit indicated activities to:
 - 1. Project mobilization.
 - 2. Submittal and approval of shop drawings and samples.
 - 3. Procurement of equipment and critical materials.
 - 4. Fabrication of special material and equipment, and its installation and testing.
 - 5. Final cleanup.
 - 6. Final inspecting and testing.
 - 7. All activities by the Engineer that affect progress, required dates for completion, or both, for all and each part of the Work.

PART 3 - EXECUTION

3.1 PRELIMINARY ANALYSIS

- A. Contents:
 - 1. Show all activities of the Contractor under this Work for the period between receipt of Notice to Proceed and submittal of construction schedule.
 - 2. Show the Contractor's general approach to remainder of the Work.
 - 3. Show cost of all activities scheduled for performance before submittal and approval of the construction schedule.

3.2 CONSTRUCTION SCHEDULE

- A. Provide a construction schedule incorporating all revisions from review of the preliminary analysis.

3.3 PERIODIC REPORTS

- A. Provide monthly updates of the approved construction schedule.
 - 1. Indicate "actual" progress for each activity on the bar chart.
 - 2. Provide written narrative summary of revisions causing delay in the program, and an explanation of corrective actions taken or proposed.

3.4 REVISIONS

- A. Make periodic revisions to the schedule to incorporate delays, early completion, etc.

- B. Make only those revisions to approved construction schedule as are approved in advance by the Engineer.

END OF SECTION

SECTION 01340

SHOP DRAWINGS, PRODUCT DATA AND SAMPLES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Work included: Make submittals required by the Contract Documents and revise and resubmit as necessary to establish compliance with the specified requirements.
- B. Related work:
 - 1. Documents affecting work of this Section include, but are not necessarily limited to, General Conditions, Supplementary Conditions, and Sections in Division 1 of these specifications.
 - 2. Individual requirements for submittals also may be described in pertinent sections of these specifications.
- C. Work not included:
 - 1. Unrequired submittals will not be reviewed by the Engineer.
 - 2. The Contractor may require his subcontractors to provide drawings, setting diagrams, and similar information to help coordinate the work, but such data shall remain between the Contractor and his subcontractors and will not be reviewed by the Engineer.

1.2 QUALITY ASSURANCE

- A. Coordination of submittals:
 - 1. Prior to each submittal, carefully review and coordinate all aspects of each item being submitted.
 - 2. Verify that each item and the submittal for it conform in all respects with the specified requirements.
 - 3. By affixing the Contractor's signature to each submittal, certify that this coordination has been performed.
- B. The following products do not require further approval except for interface within the Work and where otherwise indicated.
 - 1. Products specified by reference to standard specifications such as ASTM, AWWA, and similar standards.
 - 2. Products specified by manufacturer's name and catalog model number.
- C. "Or equal":
 - 1. Where the phrase "or equal" occurs in the Contract Documents, do not assume that the materials, equipment or methods will be considered as equal unless the item has been specifically so approved for this Work by the Engineer.
 - 2. The decision of the Engineer shall be final.
- D. The Engineer shall assume that no shop drawing or related submittal comprises a variation unless the Contractor advises the Engineer otherwise in writing.

1.3 SUBMITTALS

- A. Within 10 working days after the Contractor has received the Owner's notice to proceed, submit:

1. Schedule for submittals including specification section, type of submittal and submittal date.
 2. Construction schedule.
 3. Schedule of partial payment requests.
- B. Make submittals of shop drawings, samples, substitution requests and other items in accordance with the provisions of this Section.

PART 2 - PRODUCTS

2.1 SHOP DRAWINGS

- A. Scale and measurements: Make shop drawings accurately to a scale sufficiently large to show all pertinent aspects of the item and its method of connection to the Work.
- B. Large prints (11" x 17" or larger):
1. Submit shop drawings in the form of white copies.
 2. Blueprints will not be acceptable.
- C. Manufacturer's literature:
1. Where contents of submitted literature from manufacturers includes data not pertinent to the submittal, clearly show which portions of the contents are being submitted for review.
 2. Submit the number of copies which are required to be returned, plus four copies of electrical and three copies of all other submittals which will be retained by the Engineer.
- D. Number of copies:
1. Submit the number of copies which are required to be returned, plus three copies which will be retained by the Engineer.
 2. Electrical shop drawings: submit the number of copies which are required to be returned, plus four copies which will be retained by the Engineer.
- E. Do not begin fabrication of equipment or materials prior to Engineer's approval of shop drawings.

2.2 COVER LETTER

- A. Provide a cover letter with each submittal stipulating where the item submitted does not comply with the full extent of the specifications.
- B. Provide an explanation of why the item(s) submitted are considered to be equal to the item(s) specified.
- C. Failure to submit a cover letter will result in rejection of the submittal.

2.3 SAMPLES

- A. Provide sample or samples identical to the precise article proposed to be provided. Identify as described under "Identification of submittals" below.
- B. Number of samples required:
1. Unless otherwise specified, submit samples in the quantity which is required to be returned, plus one which will be retained by the Engineer.
 2. By prearrangement in specific cases, a single sample may be submitted for review and, when approved, be installed in the work at a location agreed upon by the Engineer.

2.4 COLORS AND PATTERNS

- A. Unless the precise color and pattern is specifically called out in the Contract Documents, and whenever a choice of color or pattern is available in the specified products, submit accurate color and pattern charts to the Engineer for selection.

PART 3 - EXECUTION

3.1 CONTRACTOR'S REVIEW OF SUBMITTALS

- A. Before submitting a shop drawing or any related material, Contractor shall:
 - 1. Review each such submission for conformance with the means, methods, techniques, sequences, and operations of construction, and safety precautions and programs incidental thereto, all of which are the sole responsibility of Contractor.
 - 2. Approve each such submission before submitting it.
 - 3. Stamp each such submission before submitting it.
- B. Shop drawings and related materials shall be returned with comments provided that each submission has been specified and is stamped by the Contractor.
- C. Shop drawings or material not specified or which have not been approved by the Contractor shall be returned without comment.
- D. Contractor is to utilize the following stamp on all shop drawing submittals:

This shop drawing has been reviewed by [NAME OF CONTRACTOR] and approved with respect to the means, methods, techniques, sequences, and procedures of construction, and safety precautions and programs incidental thereto. [NAME OF CONTRACTOR] also warrants that this shop drawing complies with contract documents and comprises no variations thereto.	
By:	_____
Date:	_____

3.2 IDENTIFICATION OF SUBMITTALS

- A. Consecutively number all submittals.
 - 1. When material is resubmitted for any reason, transmit under a new letter of transmittal and with a new transmittal number.
 - 2. On resubmittals, cite the original submittal number for reference.
- B. Accompany each submittal with a letter of transmittal showing all information required for identification and checking.
- C. On at least the first page of each submittal, and elsewhere as required for positive identification, show the submittal number in which the item was included.
- D. Maintain an accurate submittal log for the duration of the work, showing current status of all submittals at all times. Make the submittal log available to the Engineer for his review upon request.

3.3 GROUPING OF SUBMITTALS

- A. Unless otherwise specified, make submittals in groups containing all associated items to assure that information is available for checking each item when it is received.

1. Partial submittals may be rejected as not complying with the provisions of the Contract.
2. The Contractor may be held liable for delays so occasioned.

3.4 TIMING OF SUBMITTALS

- A. Make submittals far enough in advance of scheduled dates for installation to provide time required for reviews, for securing necessary approvals, for possible revisions and resubmittals, and for placing orders and securing delivery.
- B. In scheduling, allow at least ten working days for review by the Engineer following his receipt of the submittal.

3.5 RESUBMITTAL SCHEDULE

- A. For submittals marked "Furnish as Corrected" by the Engineer, resubmittal shall be within ten (10) working days of the review date shown on the Engineer's shop drawing review stamp.
- B. For submittals marked "Revise and Resubmit", "Submit Specified Item", or "Rejected", resubmittal shall be within ten (10) working days of the review date shown on the Engineer's shop drawing review stamp.

3.6 ENGINEER'S REVIEW

- A. Review by the Engineer does not relieve the Contractor from responsibility for errors which may exist in the submitted data.
- B. Revisions:
 1. Make revisions required by the Engineer.
 2. If the Contractor considers any required revision to be a change, he shall so notify the Engineer as provided for in Paragraph 17 of the General Conditions.
 3. Make only those revisions directed or approved by the Engineer.
 4. Submittals which have been reviewed and returned to the Contractor marked "Revise and Resubmit" or "Rejected" and which are resubmitted and not in an approvable state, will not be reviewed a third time unless payment for the third and any subsequent review is by the Contractor. The engineering costs for review shall be equal to the Engineer's charges to the Owner under the terms of the Engineering Agreement with the Owner.

END OF SECTION

SECTION 01500

TEMPORARY FACILITIES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Work included: Provide temporary facilities needed for the work including, but not necessarily limited to:
 - 1. Temporary utilities such as heat, water, electricity, and telephone.
 - 2. Sanitary facilities.
- B. Related work:
 - 1. Documents affecting work of this Section include, but are not necessarily limited to, General Conditions, Supplementary Conditions, and Sections in Division 1 of these specifications.
 - 2. Permanent installation and hookup of the various utility lines are described in other Sections.

1.2 PRODUCT HANDLING

- A. Maintain temporary facilities in proper and safe condition throughout progress of the work.

PART 2 - PRODUCTS

2.1 UTILITIES

- A. Water:
 - 1. Provide necessary temporary piping and water supply and, upon completion of the work, remove such temporary facilities.
 - 2. Provide and pay for water used in construction.
- B. Electricity:
 - 1. Provide necessary temporary wiring and, upon completion of the work, remove such temporary facility.
 - 2. Provide and pay for electricity used in construction.
- C. Heating: Provide and maintain heat necessary for proper conduct of operations needed in the work.

2.2 FACILITIES

- A. Sanitary facilities:
 - 1. Provide temporary sanitary facilities in the quantity required for use by all personnel.
 - 2. Maintain in a sanitary condition at all times.
 - 3. Strictly enforce their use.

2.4 CONFINED SPACE SAFETY EQUIPMENT

- A. Work under this contract may require construction or work in a confined space, defined as any space having one or more of the following characteristics:
 - 1. Limited openings for entry and exit.
 - 2. Unfavorable natural ventilation.
 - 3. Not designed for continuous worker occupancy.
- B. The Contractor shall have on the job site at all times the following minimum safety equipment:
 - 1. Gas monitor capable of testing and detecting for combustible gas, oxygen deficiency and hydrogen sulfide.
 - 2. Confined space access and retrieval winch system.
 - 3. Ventilating fan with large diameter ventilating hose.
 - 4. Supplied air respirator, MSHA/NIOSH approved type.
 - 5. Safety harness and life lines.
- C. This equipment to be available for use by the Contractor, Engineer and Owner for the duration of the project.
- D. All entries into or work within confined spaces to be conducted in accordance with the U.S. Department of Health and Human Services/National Institute for Occupational Safety and Health [DHHS (NIOSH)] Publication No. 87-113, A Guide to Safety in Confined Spaces.

PART 3 - EXECUTION

3.1 MAINTENANCE AND REMOVAL

- A. Maintain temporary facilities and controls as long as needed for safe and proper completion of the work.
- B. Remove such temporary facilities and controls as rapidly as progress of the work will permit, or as directed by the Engineer.

END OF SECTION

SECTION 01640

PRODUCT HANDLING

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Work included: Protect products scheduled for use in the work by means including, but not necessarily limited to, those described in this Section.
- B. Related work:
 - 1. Documents affecting work of this Section include, but are not necessarily limited to, General Conditions, Supplementary Conditions, and Sections in Division 1 of these specifications.
 - 2. Additional procedures also may be prescribed in other Sections of these specifications.

1.2 QUALITY ASSURANCE

- A. Include within the Contractor's quality assurance program such procedures as are required to assure full protection of work and materials.

1.3 MANUFACTURERS' RECOMMENDATIONS

- A. Except as otherwise approved by the Engineer, determine and comply with manufacturer's recommendations on product handling, storage and protection.

1.4 PACKAGING

- A. Deliver products to the job site in their manufacturer's original container, with labels intact and legible.
 - 1. Maintain packaged materials with seals unbroken and labels intact until time of use.
 - 2. Promptly remove damaged material and unsuitable items from the job site and promptly replace with material meeting the specified requirements, at no additional cost to the Owner.
- B. The Engineer may reject as non-complying such material and products that do not bear identification satisfactory to the Engineer as to manufacturer, grade, quality and other pertinent information.

1.5 PROTECTION OF MATERIAL AND WORK

- A. General:
 - 1. Carefully and properly protect all materials of every description, both before and after being used in the Work in accordance with manufacturer's recommendations.
 - 2. Provide any enclosing or special protection from weather deemed necessary by the Engineer at no additional cost to the Owner.
- B. Partial payments under the Contract will not relieve the Contractor from responsibility.
 - 1. When materials and work at the site that have been partially paid for are not adequately protected by the Contractor, such materials will be protected by the Owner at the expense of the Contractor and no further partial payment thereon will be made.
- C. Maintain finished surfaces clean, unmarred, and suitably protected until accepted by the Owner.

1.6 STORAGE

- A. Store all items of equipment, component parts, etc., in accordance with the manufacturers' recommendations or as may otherwise be necessary to prevent damage or deterioration of any sort.
- B. Electrical and control equipment:
 - 1. Store in a dry area protected from dust and humidity.
 - 2. Equipment can be protected by a weatherproof cover if shipped to the site no more than two (2) weeks prior to installation and energization.

1.7 REPAIRS AND REPLACEMENTS

- A. In the event of damage, promptly make replacements and repairs to the approval of the Engineer and at no additional cost to the Owner.
- B. Additional time required to secure replacements and to make repairs will not be considered by the Engineer to justify an extension in the contract time of completion.

PART 2 – PRODUCTS (NOT APPLICABLE)

PART 3 – EXECUTION (NOT APPLICABLE)

END OF SECTION

SECTION 01650

GENERAL EQUIPMENT REQUIREMENTS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Requirements relating to providing of equipment and services specified in other Sections of these specifications.
- B. Related work:
 - 1. Documents affecting work of this Section include, but are not necessarily limited to, General Conditions, Supplementary Conditions, and Sections of Division 1 of these Specifications.
 - 2. Additional provisions concerning this work may be stated in other sections of these specifications.
 - 3. Where new equipment is to be installed into existing structures or systems, verify the plan dimensions with existing dimensions and note any discrepancies on the shop drawings.
- C. Allotted space and modifications:
 - 1. Equipment furnished under this Section shall be installed at the location and in the space allotted on the Contract Drawings.
 - 2. Any structural, piping, wiring, drawings, or other modifications required to accommodate equipment offered other than that shown on the Drawings, or specified, shall be done at no additional cost to the Owner.

1.2 QUALITY ASSURANCE

- A. Equipment manufacturers shall, upon request of the Engineer, provide a detailed list of installations of comparable function.
- B. Equipment in each Section shall be by a single manufacturer regularly engaged in the development of equipment designed for the intended function.
- C. Guarantee the availability of repair parts and service for a period of not less than ten (10) years.
 - 1. Provide each component with a serial number and the manufacturer shall maintain records of same.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Supply all materials, tools, equipment, labor and supervision to properly complete installation of equipment, piping, controls, etc., in compliance with the contract documents.

2.2 IDENTIFICATION

- A. Provide stamped identification labels on motors and equipment with pertinent information including serial numbers, model numbers, capacities, voltage, amps, etc.
- B. Label to be aluminum or stainless steel.
- C. Attach with stainless steel or aluminum hardware.

2.3 LUBRICANTS AND LUBRICATING EQUIPMENT

- A. Provide and install necessary oils, greases, etc., for initial operation of equipment.
- B. Where manufacturer's recommendations include changing of initial lubricants after 1,000 hours or less of operation, provide sufficient lubricants to make the change.
- C. Provide one of every type lubricating gun required to properly maintain the equipment.

2.4 OPERATION, MAINTENANCE AND SERVICE MANUALS

- A. Prepare and submit for the Owner's use six (6) copies of O&M Manual for each piece of equipment.
 - 1. Submit Manuals 60 days prior to delivery of equipment.
- B. Manuals shall be specific to the equipment supplied.
 - 1. Manuals applicable to many different configurations and which require the operator to selectively read portions of the instructions will not be accepted.
 - 2. The equipment model that the Manual applies to shall be indicated by an arrow.
- C. Provide a Table of Contents specific to each Manual.
- D. At the beginning of each Manual, provide a description of the equipment to include model numbers, purchase order numbers, serial numbers, motor information, and performance and design criteria.
- E. Correlate Manuals with the approved shop drawings and include the following minimum information:
 - 1. Parts list, including recommended spare parts list.
 - 2. Guaranties.
 - 3. Recommended maintenance instructions.
 - 4. Recommended lubricants and lubrication instructions.
 - 5. Address and telephone number of the source for repairs, spare parts and service.
 - 6. Detailed description of operating procedure for the item of equipment specifically written for this installation, including start-up and shutdown procedures.
 - 7. Equipment performance specifications, including pump curves.
 - 8. Results of start-up and any further recommendations resulting from start-up.
 - 9. Current cost for each recommended spare part and agreement to provide updated costs at Owner's request.
- F. Provide a maintenance and lubrication schedule to be a summary of all preventative maintenance and lubrication, including the following information:
 - 1. Title.
 - 2. Type of activity (inspection, adjustment, oil change, etc.).
 - 3. Brief description of activity.
 - 4. Type of lubricant.
 - 5. Frequency (daily, weekly, etc.).
- G. The manufacturer shall provide the Owner with a log chart to record all servicing and maintenance required during the equipment warranty period.
- H. For process oriented equipment, treatment plants, etc., provide a detailed description of the process operation and trouble-shooting of problems.
- I. Provide clear and legible copies. Type parts lists, etc.
- J. Layout and detail drawings shall be reduced to a maximum size of 11" x 17", unless written approval is received from the Engineer prior to submittal of Manuals.

- K. Provide a clearly labeled three-ring binder for Manuals having a thickness greater than 1/4". Provide sheet lifters if binder is more than 2/3 full.
 - 1. Provide multiple binders for Manuals having a thickness greater than 2".

PART 3 - EXECUTION

3.1 GENERAL

- A. Provide information that may be requested without undue delay.
- B. Deliver O&M Manuals to the Engineer for review and approval and transmittal to the Owner.
 - 1. Do not start equipment unless the Owner has approved O&M Manuals.
- C. Properly lubricate all equipment prior to start-up.
- D. Work under sections requiring submittal of O&M Manual will not be considered complete and final payment will not be made until all Manuals have been submitted and approved.
- E. Provide revisions to O&M Manuals to reflect any changes made during installation and start-up of equipment.

3.2 WARRANTY PERIOD

- A. Equipment warranties shall commence upon successful completion of the thirty (30) day operational period after project acceptance by Owner and shall be for a period of one (1) year.
- B. Contractor will be notified in writing of beginning and ending dates of warranty period.

END OF SECTION

SECTION 01660

TECHNICAL SERVICES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Work included: Providing technical services to ensure proper installation and training of Owner's personnel in operational procedures for various items of equipment.
- B. Related work:
 - 1. Documents affecting work of this Section include, but are not necessarily limited to, General Conditions, Supplementary Conditions, and Sections in Division 1 of these Specifications.
 - 2. Other requirements for technical services are stated in other Sections of these Specifications.

1.2 QUALITY ASSURANCE

- A. Provide services of qualified service engineers, process engineers, or technicians only.
- B. Qualifications of personnel provided shall be subject to approval of the Engineer.
 - 1. Services of personnel found not to be qualified will not be considered a part of the period of service specified.

1.3 SUBMITTALS

- A. Provide credentials of all process engineers for approval 30 days prior to their scheduled period of service.

PART 2 - PRODUCTS

2.1 REPORTS

- A. Provide written copies of reports, certified results of tests, etc. complying with other Sections of these Specifications.

PART 3 - EXECUTION

3.1 GENERAL

- A. Where service is required by a manufacturer, it shall be extended to all other items of equipment provided by him, whether individually specified or not.
- B. A day of service is defined as not less than 8 working hours performed between 7:00 a.m. and 7:00 p.m., unless otherwise required.
- C. A trip is defined as a scheduled visit to the project site for the express purpose of providing technical services specified.
- D. Travel time to or from the project site is not a part of the service time.

3.2 PERIOD OF SERVICE

- A. Provide number of days service and number of trips as indicated in individual equipment sections.

3.3 FIELD MEASUREMENTS

- A. Measure and record amperage, voltage, and speed (rpm) at operating conditions of the equipment.
- B. Include all measurements of the equipment.

END OF SECTION

SECTION 01670

START-UP SERVICES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Work included: Provide personnel to place all equipment in operation, fine tune treatment processes and instruct Owner's personnel in operation and maintenance procedures.
- B. Related work:
 - 1. Documents affecting work of this Section include, but are not necessarily limited to, General Conditions, Supplementary Conditions, and Sections in Division 1 of these specifications.
 - 2. Other provisions concerning Start-up Services may also be stated in other Sections of these specifications.

1.2 QUALITY ASSURANCE

- A. Use adequate numbers of skilled personnel who are thoroughly trained and experienced in the necessary procedures and who are completely familiar with the specified requirements and the methods needed for proper performance of the work of this Section.
- B. Provide manufacturers technical services as specified or needed.

PART 2 - PRODUCTS

- A. No products required.

PART 3 - EXECUTION

3.1 GENERAL

- A. Upon final completion of all components, the Contractor shall be responsible for placing the plant in initial operation.
- B. Provide personnel on the job site for first 30 days of operation, or until successful operation is attained, whichever is the longest.

3.2 SCHEDULING

- A. Determine date of start-up jointly with Engineer and Owner.
- B. Schedule services of manufacturers technical personnel jointly with Engineer prior to date of start-up.

3.3 FIELD MEASUREMENTS

- A. Measure and record amperage, voltage, and speed (rpm) at operating conditions of the equipment.
- B. Include all measurements in the start-up report.

3.4 COMPLETION

- A. Start-up services will not be considered completed until all equipment is operating properly and treatment processes are functioning as designed.

END OF SECTION

SECTION 01700

CONTRACT CLOSEOUT

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Work included shall be providing compliance with the requirements of the General Conditions of these Specifications for administrative procedures in closing out the project work.
- B. Related work:
 - 1. Documents affecting work of this Section include, but are not necessarily limited to, General Conditions, Supplementary Conditions, and Sections in Division 1 of these Specifications.
 - 2. Other requirements for technical services are stated in other Sections of these Specifications.
 - 3. Section 01660 - Technical Services.
 - 4. Section 01670 - Start-up Services.
 - 5. Section 01720 - Project Record Documents.

1.2 SUBSTANTIAL COMPLETION

- A. The Contractor shall notify the Engineer that, in his opinion, the project is substantially complete. A written statement listing items complete shall be submitted.
- B. Upon receipt of the Contractor's notice, the Engineer shall make an observation to determine if substantial completion is provided.
- C. If, in the Engineer's opinion, the project is not substantially complete, a written notice to the Contractor shall follow outlining reasons and deficiencies in work that comprised the Engineer's decision. The Engineer's decision shall be final.

1.3 FINAL OBSERVATION

- A. The Engineer will make a final observation for the Contractor after all items noted in the substantial completion observation have been corrected. The Contractor shall notify the Engineer in writing when a final observation is needed. Incomplete and/or defective work shall be given to the Contractor by written notice.

1.4 REOBSERVATION

- A. Re-observation required due to failure by the Contractor to make previously noted corrections will be performed by the Engineer.
- B. Cost for such observations will be due to and payable by the Contractor at a rate equal to charges to the Owner for similar work.
- C. Re-observations will continue until the work is acceptable to the Engineer.

1.5 COMPLETION BY CONTRACTOR

- A. When the Engineer finds the Contractor's work acceptable, the Contractor shall be given such notice and should proceed with closeout submittals.
- B. Closeout submittals shall contain at least the following:

1. Project record documents.
2. Equipment operation and maintenance manuals and copies of start-up reports.
3. Warranties and bonds.
4. Keys and keying schedule.
5. Spare parts and manuals.
6. Evidence of payment and release to liens per General Conditions.
7. Section 00690 - Contractor's Affidavit.

1.6 FINAL PAYMENT

- A. Final payment to the Contractor will be made upon completion of the previous items and others required by these specifications. A final statement shall be forwarded to the Engineer. The statement shall address:
1. Previous change orders.
 2. Unit prices.
 3. Deductions for uncorrected work.
 4. Deductions for liquidated damages.
 5. Deductions for re-testing work.
 6. Deductions for re-observation.
 7. Deductions for shop drawing review.
 8. Adjusted contract sum.
 9. Previous payments.
 10. Amount due.
- B. When required, the Engineer will prepare a contract change order for adjustments not previously made.

PART 2 – PRODUCTS - Not Applicable

PART 3 – EXECUTION - Not Applicable

END OF SECTION

SECTION 01720

PROJECT RECORD DOCUMENTS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Work included:
 - 1. Throughout progress of the Work, maintain an accurate record of changes in the Contract Documents, as described in Article 3.1 below.
 - 2. Upon completion of the Work, deliver the recorded changes to the Engineer.
- B. Related work:
 - 1. Documents affecting work of this Section include, but are not necessarily limited to, General Conditions, Supplementary Conditions, and Sections in Division 1 of these specifications.
 - 2. Other requirements affecting Project Record Documents may appear in pertinent other Sections of these specifications.

1.2 QUALITY ASSURANCE

- A. Delegate the responsibility for maintenance of Record Documents to one person on the Contractor's staff as approved by the Engineer.
- B. Accuracy of records shall be such that future search for items shown on the Project Record Documents may rely reasonably on the information provided under this Section of the Work.

1.3 SUBMITTALS

- A. The Engineer's approval of the current status of Project Record Documents may be a prerequisite to the Engineer's approval of requests for progress payment and request for final payment under the Contract.
- B. Prior to submitting each request for progress payment, secure the Engineer's approval of the current status of the Project Record Documents.
- C. Prior to submitting request for final payment, submit the final Project Record Documents to the Engineer and secure his approval.

1.4 PRODUCT HANDLING

- A. Maintain the job set of Record Documents completely protected from deterioration and from loss and damage until completion of the Work and transfer to the Engineer.
- B. In the event of loss of recorded data, use means necessary to again secure the data to the Engineer's approval.
 - 1. Such means shall include, if necessary in the opinion of the Engineer, removal and replacement of concealing materials.
 - 2. In such case, provide replacements to the standards originally required by the Contract Documents.

PART 2 - PRODUCTS

2.1 JOB SET DOCUMENTS

- A. Promptly following receipt of the Owner's Notice to Proceed, secure from the Engineer, at no charge to the Contractor, one complete set of all Documents comprising the Contract.

PART 3 - EXECUTION

3.1 MAINTENANCE OF JOB SET

- A. Immediately upon receipt of the job set described in above paragraph titled "JOB SET DOCUMENTS", identify each of the Documents with the title, "RECORD DOCUMENTS - JOB SET".
- B. Preservation:
 - 1. Considering the Contract completion time, the probable number of occasions upon which the job set must be taken out for new entries and for examination, and the conditions under which these activities will be performed, devise a suitable method for protecting the job set to the approval of the Engineer.
 - 2. Do not use the job set for any purpose except entry of new data and for review by the Engineer.
 - 3. Maintain the job set at the site of Work as that site is designated by the Engineer.
- C. Making entries on Job Set Drawings:
 - 1. Use erasable colored pencil, preferably red (not ink or indelible pencil) to delineate changes.
 - 2. Show by station number location of all fittings, manholes, valves, wye locations, etc.
 - 3. Reference all fittings and valves to two aboveground items reasonably safe from being relocated and indicate such references on the drawings.
 - 4. Show location of electrical conduit, pull boxes, etc.
- D. Submittal:
 - 1. Submit "marked-up" set of drawings to the Engineer.
 - 2. Make any necessary additions as required by the Engineer.

END OF SECTION

SECTION 02060

DEMOLITION

PART 1 – GENERAL

1.1 DESCRIPTION

- A. Work Included: Demolish and remove from the site those items so indicated on the drawings, including buildings, building pads, parking and roadway areas, miscellaneous structures, poles, walls, utilities, signs, etc.
- B. Related Work:
 - 1. Documents affecting work of this section include, but are not necessarily limited to, General Conditions, Supplementary Conditions, and sections in Division 1 of these specifications.

1.2 QUALITY ASSURANCE

- A. Use adequate numbers of skilled workmen who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the work of this section.
- B. Comply with the Standard Building Code with due regard to the protection of the public and the provision of safeguards during the performance of the work.
- C. Use equipment adequate in size, capacity, and numbers to accomplish the work in a timely manner.
- D. Comply with requirements of governmental agencies having jurisdiction.
- E. Contractor is responsible for being aware of and complying with the Asbestos NESHAP regulations, as well as other applicable codes, laws, and regulations.
 - 1. The Owner is to be notified immediately upon discovery of asbestos materials.

PART 2 – PRODUCTS

Not used.

PART 3 – EXECUTION

3.1 SURFACE CONDITIONS

- A. Examine the areas and conditions under which work of this section will be performed. Correct conditions detrimental to the safe, timely, and proper completion of the work. Do not proceed until unsatisfactory conditions are corrected.

3.2 DEMOLITION

- A. General
 - 1. Prior to start of demolition, carefully study the drawings and these specifications.
 - 2. In company with the owner's representative, visit the site and verify the extent of demolition to be performed under this contract.
- B. Using only the means and equipment approved for this purpose by the government agencies having jurisdiction, demolish and completely remove from the job site the existing construction designated to be removed.
 - 1. Shut off, cap, reroute, and otherwise protect existing public utility lines in accordance with the requirements of the public agency or utility having jurisdiction.
 - 2. Remove rocks larger than 2" diameter, roots, wood, and debris.
- C. Demolished material shall be considered to be property of the contractor and shall be completely removed from the job site.
- D. Use means necessary to prevent dust from becoming a nuisance to the public, to neighbors, and to other work being performed on or near the site.
- E. Use appropriate means necessary to protect the public safety during the demolition process.
- F. Use appropriate means necessary to protect the adjacent structures from damage during demolition.
- G. Erosion Control: Construct and maintain erosion control as shown on the drawings and in accordance with the local county's requirements.

END OF SECTION

SECTION 02221

TRENCHING & BACKFILLING FOR UTILITIES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Work included: Trench, backfill, and compact as specified herein and as needed for installation of underground utilities associated with the Work.
- B. Related work:
 - 1. Documents affecting work of this Section include, but are not necessarily limited to, General Conditions, Supplementary Conditions and Sections in Division 1 of these Specifications.
 - 2. Section 16400 - Electrical.

1.2 QUALITY ASSURANCE

- A. Use adequate numbers of skilled workmen who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the work of this Section.
- B. Use equipment adequate in size, capacity, and numbers to accomplish the work in a timely manner.

1.3 JOB CONDITIONS

- A. Existing utilities:
 - 1. There now exists in the construction areas, waterworks, storm drainage, sanitary sewers, street paving, gas mains and other utilities.
 - 2. Approximate location of certain underground lines and structures are shown on the plans for information only, other underground lines or structures are not shown.
 - 3. Locate these and other possible unknown utility lines using electronic pipe finder, or other approved means.
 - 4. Locate, excavate and expose all existing underground lines in advance of trenching operations.
 - 5. The Contractor will be held responsible for the workmanlike repair of any damage done to any of these utilities in the execution of his work under this Section.
 - 6. The Contractor shall familiarize himself with the existing conditions and be prepared to adequately care for and safeguard himself and the Owner from damage.
- B. Notification of intent to excavate:
 - 1. South Carolina Underground Utility Damage Prevention Act (S.C. Code Ann, 58-35-10, CT-SEQ, Supp. 1978) requires persons to ascertain the location of underground public utility property prior to excavation or demolition in certain situations. The Act also requires such

persons to give timely notice of intent to excavate or demolish prior to commencing such operations. Failure to comply could subject the violator to a civil penalty of up to one thousand dollars (\$1,000) for each violation of the Act.

2. Notification of intent to excavate may be given by calling SC 811 by dialing 811 within SC or this toll free number: 1-888-721-7877.

C. Protecting trees, shrubbery and lawns:

1. Trees and shrubbery in developed areas and along the trench line shall not be disturbed unless absolutely necessary, and subject to the approval of the Engineer.
 - a. Any such trees and shrubbery necessary to be removed shall be heeled in and replanted.
2. Where trenches cross private property through established lawns, sod shall be cut, removed, stacked and maintained in suitable condition until replacement is approved by the Engineer.
 - a. Topsoil underlying lawn areas shall be removed and kept separate from general excavated materials.

D. Clearing:

1. Perform all clearing necessary for installation of the complete work.
2. Clearing shall consist of removing all trees, stumps, roots, brush and debris in the rights-of-way obtained for the Work.
3. All timber of merchantable size shall remain the property of the Owner and shall be trimmed and cut in such lengths as directed and stacked along the edge of the right-of-way.
4. All other material, including trimmings from above, shall be completely disposed of in a satisfactory manner.

E. Removing and resetting fences:

1. Where existing fences must be removed to permit construction of utilities:
 - a. Remove such fences and, as the Work progresses, reset the fences in their original location and condition.
 - b. Provide temporary fencing or other safeguards as required to prevent stock and cattle from wandering to other lands.

F. Restoration of disturbed areas:

1. Restore all areas disturbed by, during or as a result of construction activities to their existing or better condition.
 - a. For existing areas with sod type grasses, replace with new sod. Existing sod may be reused where properly removed and stored.
2. Do not interpret this as requiring replacement of trees and undergrowth in undeveloped sections of the rights-of-way.

- G. Minimizing silting and bank erosion during construction:
 - 1. During construction, protective measures shall be taken and maintained to minimize silting and bank erosion of creeks and rivers adjacent to the work being performed during construction.

- H. Blasting:
 - 1. Store all explosives in a secure manner, complying with all laws, ordinances, and regulations.
 - 2. Contractor shall be responsible for damage caused by blasting operations.

PART 2 - PRODUCTS

2.1 EXCAVATED MATERIALS

- A. Perform all excavation of every description and of whatever substances encountered to depths indicated or specified.
- B. Pile material suitable for backfilling in an orderly manner at safe distance from banks or trenches to avoid overloading and to prevent slides or cave-ins.
- C. Remove and deposit unsuitable or excess materials as directed by the Engineer.

2.2 BACKFILL MATERIALS

- A. Provide from materials excavated for installation of utility.
 - 1. Select soil material free from organic matter and deleterious substances, containing no rocks or lumps over 2" in greatest dimension for backfill up to 12" above top of utility being covered.
 - 2. Do not permit rocks larger than 2" in greatest dimension in top 6" of backfill.

2.3 OTHER MATERIALS

- A. Provide other materials, not specifically described but required for a complete and proper installation, as selected by the Contractor subject to the approval of the Engineer.
- B. Should the quantity of suitable on-site material be insufficient to complete the work, provide suitable borrow material as approved by the Engineer at no additional expense to the Owner.
- C. Provide select materials from on-site if acceptable material as approved by the Engineer is available on-site. Otherwise, provide approved select material from an off-site source.

PART 3 - EXECUTION

3.1 PROCEDURES

- A. Existing utilities:
1. Unless shown to be removed, protect active utility lines shown on the drawings or otherwise made known to the Contractor prior to trenching. If damaged, repair or replace at no additional cost to the Owner.
 2. If active utility lines are encountered and are not shown on the Drawings or otherwise made known to the Contractor, promptly take necessary steps to assure that service is not interrupted.
 3. If service is interrupted as a result of work under this Section, immediately restore service by repairing the damaged utility at no additional cost to the Owner.
 4. If existing utilities are found to interfere with the permanent facilities being constructed under this Section, immediately notify the Engineer and secure his instructions.
 5. Do not proceed with permanent relocation of utilities until written instructions are received from the Engineer.
- B. Locations within streets or highways:
1. Comply with South Carolina Department of Transportation's (SCDOT) "Encroachment Permit" issued for the Work, and the South Carolina Department of Transportation's (SCDOT) "*A Policy for Accommodating Utilities on Highway Rights-of-Way*".
 2. Take all precautions and comply with all requirements as may be necessary to protect the improvements, including barricades for protection of traffic.
 3. Keep minimum of one lane open to traffic at all times where utility crosses street or highway.
- C. Protection of persons and property:
1. Barricade open holes and depressions occurring as part of the Work, and post warning lights on property adjacent to or with public access.
 2. Operate warning lights during hours from dusk to dawn each day and as otherwise required.
 3. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, washout and other hazards created by operations under this Section.
- D. Dewatering:
1. Remove all surface and subsurface waters from excavations and maintain the excavation in a dry condition during construction operations.
 2. Maintain the ground water level a minimum of 3-feet below the trench bottom during excavation, installation and backfilling.
 - a. Material disturbed below the invert elevation due to improper dewatering shall be removed and replaced with crushed stone or lean concrete at no expense to the Owner.

- b. Use sumps, pumps, drains, trenching, wells, vacuum or well point system as necessary to maintain the ground water level a minimum of 3-feet below the trench bottom and maintain a dry excavation.
 - c. Dewatering by trench pumping will not be permitted if migration of fine grained natural material (running sand) from bottom, side walls or bedding material will occur.
 - d. Provide monitoring wells sufficient in size, location, number and depth to monitor the ground water level in the construction area during excavation and backfill operations.
 - e. Maintain dewatering operations until backfilling and compaction operations are complete.
3. Dispose of water pumped from excavations in storm drains having capacity, canals, trenches or other approved locations.
- a. Contractor is responsible for acquiring all permits required to discharge the water and shall protect waterways from turbidity during the operation.
 - b. Prevent flooding of streets, roadways, or private property.
 - c. Provide engines driving dewatering pumps with residential type mufflers.
- E. Use means necessary to prevent dust becoming a nuisance to the public, to neighbors, and to other work being performed on or near the site.
- F. Maintain access to adjacent areas at all times.

3.2 TRENCH EXCAVATION (Unclassified)

- A. Remove all materials of whatever substance encountered.
- B. Where trenching occurs in existing lawns, remove turf in sections and keep damp. Replace turf upon completion of the backfilling.
- C. Open cut:
 - 1. Excavate for utilities by open cut.
 - 2. If conditions at the site prevent such open cut, and if approved by the Engineer, tunneling may be used.
 - 3. Short sections of a trench may be tunneled if, in the opinion of the Engineer, the conductor can be installed safely and backfill can be compacted properly into such tunnel.
 - 4. Remove boulders and other interfering objects, and backfill voids left by such removals, at no additional cost to the Owner.
 - 5. Remove wet or otherwise unstable soil incapable of properly supporting the utility, as determined by the Engineer, to depth required and backfill to proper grade with stone bedding material, at no additional cost to the Owner.
 - 6. Excavating for appurtenances:
 - a. Excavate for manholes and similar structures to a distance sufficient to leave at least 12" clear between outer surfaces and the embankment or shoring that may be used to hold and protect the banks.

- b. Overdepth excavation beyond such appurtenances that has not been directed will be considered unauthorized. Fill with sand, gravel, or lean concrete as directed by the Engineer, and at no additional cost to the Owner.
- D. Trench to the minimum width necessary for proper installation of the utility, with sides as nearly vertical as possible. Accurately grade the bottom to provide uniform bearing for the utility.
- E. Provide sheeting and shoring necessary for protection of the Work and for the safety of personnel.
 1. Remove in units when level of backfilling has reached the elevation necessary to protect the utility work and adjacent property.
 2. Sheeting at the bottom of trenches over 10' deep for sewers 15" and larger in size, shall remain in place and be cut off no less than 2" above top of pipe, at no additional cost to the Owner.
- F. Depressions:
 1. Dig bell holes and depressions for joints after the trench has been graded. Provide uniform bearing for the pipe on prepared bottom of the trench.
 2. Except where rock is encountered, do not excavate below the depth indicated or specified.
 3. Where rock is encountered, excavate rock to a minimum overdepth of 4" below the trench depth indicated or specified, and to provide 6" clearance in any horizontal direction from all parts of the utility and appurtenances.
- G. Special requirements relating to excavation for specific types of utilities shall comply with the following:
 1. Water distribution lines:
 - a. Provide depth of cover shown or minimum cover of 36", whichever is greater.
 - b. Where minimum cover only is required, carry excavations to depths necessary to properly grade the pipe on tangents and vertical curves as directed by the Engineer.
 - c. Provide minimum clearance of 6" between pipe walls and trench walls or sheeting and bracing lines.
 - d. If minimum cover of 36" cannot be provided, then thermoplastic piping may not be used. Use ductile iron piping or other Engineer-approved material.
 2. Sanitary or storm sewer lines:
 - a. Comply with requirements of Section 02722 and Section 02721.
 - b. Do not excavate trench more than 200' ahead of pipe laying, unless permitted by Engineer.
 - c. Maintain trench sides vertical to point not less than 2' above top of pipe.
 - d. Upper portion of trench may be sloped to any width which will not cause damage to adjoining structures, utilities, pavements or private property.
 3. Sewers, Sanitary Pressure: (Force Main):
 - a. Comply with requirements of Section 02723.
 - b. Grade trenches to avoid high points, unless otherwise indicated.

- c. Provide minimum cover of 36".
 - d. Provide minimum clearance of 6" between pipe walls and trench wall or sheeting and bracing lines.
 - e. If minimum cover of 36" cannot be provided, then thermoplastic piping may not be used. Use ductile iron piping or other Engineer-approved material.
4. Electrical conduit:
- a. Provide depth of cover shown or minimum cover of 36", whichever is greater.
 - b. Where minimum cover only is required, carry excavations to depths necessary to properly grade the conduit on tangents and vertical curves as directed by the Engineer.
 - c. Provide minimum clearance of 12" between conduit and trench wall or sheeting and bracing lines.
 - d. If minimum cover of 36" cannot be provided, then thermoplastic piping may not be used. Use ductile iron piping or other Engineer-approved material.
- H. Comply with pertinent OSHA regulations in regards to the excavation of utilities.

3.3 BACKFILLING

- A. General:
- 1. Backfill trenches and excavations immediately after the pipes are laid, unless other protection is directed or indicated.
 - 2. Select and deposit backfill materials with special reference to the future safety of the pipes.
 - 3. Reopen trenches which have been improperly backfilled, to a depth as required for proper compaction. Refill and compact as specified, or otherwise correct to the approval of the Engineer.
 - 4. Surplus material shall be disposed of as directed by the Engineer.
 - 5. Original surface shall be restored to the approval of the Engineer.
 - 6. Maintain proper dewatering during backfill and compaction operations.
- B. Lower portion of trench:
- 1. Deposit approved backfill and bedding material in layers of 6" maximum thickness, and compact with suitable tampers to the density of the adjacent soil until there is a cover of not less than 24" over sewers and 12" over other utility lines.
 - 2. Take special care in backfilling and bedding operations not to damage pipe and pipe coatings.
- C. Remainder of trench:
- 1. Except for special materials for pavements, backfill the remainder of the trench with material free from stones larger than 6" or 1/2 the layered thickness, whichever is smaller, in any dimension.
 - 2. Deposit backfill material in layers not exceeding the thickness specified, and compact each layer to the minimum density directed by the soil engineer.

- D. Adjacent to buildings: Mechanically compact backfill in 6" layers within ten (10') feet of buildings.
- E. Under roads, streets and other paved areas:
 - 1. Mechanically tamp in 6" layers using heavy duty pneumatic tampers or equal.
 - 2. Tamp each layer to a density equivalent of not less than 100% of an ASTM D 698 Proctor Curve.
 - 3. Provide additional compaction by leaving the backfilled trench open to traffic while maintaining the surface with crushed stone.
 - 4. Refill any settlement with crushed stone and continue such maintenance until replacement of pavement is authorized by the Engineer.
- F. Undeveloped areas:
 - 1. Backfill in wooded, swampy or undeveloped areas shall be as specified hereinbefore, except that tamping of the backfill above a level 2' over the top of the pipe will not be required.
 - 2. Mound excavated material neatly over the ditch to provide for future settlements.

3.4 MEASUREMENT AND PAYMENT

- A. No measurement or direct payment will be made for the Work under this Section.

END OF SECTION

SECTION 02930

GRASSING

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Work Included: Provide grassing of the areas specified herein, or as indicated, for a complete and proper installation.
 - 1. All areas disturbed by the construction operation.
- B. Related Work:
 - 1. Documents affecting work of this section include, but are not necessarily limited to, General Conditions, Supplementary Conditions, and sections in Division 1 of these specifications.

1.2 QUALITY ASSURANCE

- A. Use adequate numbers of skilled workmen who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the work of this section.
- B. Seed: Conform to all State laws and to all requirements and regulations of the South Carolina Department of Agriculture.
 - 1. Deliver to site each variety of seed individually packaged and tagged to show name, net weight, origin and lot number.
- C. Fertilizer: Conform to State fertilizer law.

1.3 SUBMITTALS

- A. Comply with pertinent provisions of Section 01340.

1.4 PRODUCT HANDLING

- A. Comply with pertinent provisions of Section 01640.
- B. At time of delivery, furnish the Engineer invoices of all materials received in order that application rates may be determined.
- C. Immediately remove from the site materials that do not comply with the specified requirements, and promptly replace with materials meeting the specified requirements.

PART 2 - PRODUCTS

2.1 FERTILIZER

- A. Provide a mixed fertilizer with a designation such as 10-10-10, where the first number represents the minimum percent of nitrogen required, the second number represents the minimum percent of available phosphoric acid required, and the third number represents the minimum percent of water soluble potash required in the fertilizer. For centipede grass, use only 15-0-15 or 16-4-8 fertilizer. Fertilizer shall be delivered to the site in bags labeled with the manufacturer's guaranteed analysis.

2.2 GRASS SEED

- A. Provide grass seed which is:
 - 1. Free from noxious weed seeds, and recleaned.
 - 2. Grade A recent crop seed.
 - 3. Treated with appropriate fungicide at time of mixing.
 - 4. Delivered to the site in sealed containers with dealer's guaranteed analysis.

2.3 LIME

- A. Provide agricultural grade, standard ground limestone conforming to current "Rules, Regulations and Standards of the Fertilizer Board of Control" issued at Clemson University.
- B. Bag tags or delivery slip for bulk loads shall indicate brand or trade name, calcium carbonate equivalent, and other pertinent data to identify the lime.

2.4 WOOD CELLULOSE FIBER

- A. Provide wood chip particles manufactured particularly for discharging uniformly on the ground surface when dispersed by a hydraulic water sprayer.
- B. Material to be heat processed so as to contain no germination or growth inhibiting factors.
- C. It shall be dyed (non-toxic) an appropriate color to facilitate metering.

2.5 STRAW MULCH

- A. Provide straw or hay material.
 - 1. Straw to be stalks of wheat, rye, barley or oats.
 - 2. Hay to be timothy, peavine, alfalfa, or coastal Bermuda.
- B. Material to be reasonably dry and reasonably free from mature seed bearing stalks, roots or bulblets or Johnson Grass, Nutgrass, Wild Onion, Sandburg, Wild Garlic, Wild Mustard, Crotonaria, Pigweed, Witchweed, and Cocklebur and other noxious weeds.

2.6 EXCELSIOR FIBER MULCH

- A. To consist of 4" to 6", average length, wood fibers cut from sound, green timber.

- B. Make cut in such a manner as to provide maximum strength of fiber, but at a slight angle to natural grain of the wood.

2.7 EROSION CONTROL BLANKET

- A. Provide on areas as shown on the plans.
- B. Provide Erosion Control Blanket S150, from North American Green, or approved equal.

PART 3 - EXECUTION

3.1 GENERAL

- A. Seed these areas immediately upon completion of grading or construction and clean-up operations.
 - 1. Slopes greater than four horizontal to one vertical.
 - 2. Utility rights-of-way adjacent to stream banks.

3.2 SEEDING SCHEDULES

- A. Unless otherwise provided, select the type of seeding from the tables shown below for the upper state and the lower state regions as applicable to the project. The total seed rate in pounds per acre is the sum total shown for all the varieties of seed opposite the schedule number in the seeding schedules included herein. The upper state region consists of all counties west of the counties of Aiken, Lexington, Richland, Kershaw, and Chesterfield. The lower state region consists of the above-cited counties and all counties east.
- B. Adhere to the following seeding schedules:

Seeding Schedule for Permanent Vegetation Lower State				
Schedule No.	Common Name of Seed	Pounds/acre Rural ¹	Pounds/acre Urban ¹	Planting Dates
3 ⁵	Common Bermuda (hulled) ³	30	30	March 1 to August 14
	Weeping Lovegrass ²	10	10	
	Sericea Lespedeza (scarified) ²	50	50	
	Weeping Lovegrass ²	10	10	
4 ⁵	Common Bermuda (unhulled) ³	40	40	August 15 to February 28
	Weeping Lovegrass ²	10	10	
	Sericea Lespedeza (unhulled, unscarified) ²	80	80	
	Reseeding Crimson Clover ⁴	20	0	
	Annual Rye Grass ⁵	5	15	
	Rye Grain	20	0	
5 ⁶	Centipede	10	10	March 1 to April 15

Notes:

¹ Includes rural areas adjacent to well-developed lawns.

² Not required on shoulders, medians, etc. and on slopes under 5 feet in height.

³ Do not use Giant Bermuda seed including NK-37.

⁴ Provide an inoculant for treating reseeding crimson clover seed of a pure culture of nitrogen-fixing bacteria selected for a maximum vitality and ability to transform nitrogen from the air into soluble nitrates and deposit them into the soil. Ensure that inoculants consist of purebred cultures and are not more

than one year old. Do not plant clover in medians or in rural areas adjacent to well-developed lawns.

⁵ Pensacola Bahia is allowed only as shown in Seeding Schedules 3 and 4 at the rate of 50 pounds per acre only when seeding pit areas that are governed by the South Carolina Mining Act. Otherwise, do not include Bahia seed in the mix.

⁶ Apply one-half of lime rates and one-half of maintenance fertilizer rates. Fertilize centipede at the application rate of 20 pounds per acre of 16-4-8 or 15-0-15 fertilizers in May and repeat in August.

⁷ The use of Italian Rye Grass is prohibited.

- C. The Contractor may include quantities of rye grain and millet in Schedule Nos. 1 and 3 to establish quick ground cover for erosion control purposes.

Seeding Schedule for Temporary Vegetation Upper and Lower State			
Schedule No.	Common Name of Seed	Pounds/acre	Planting Dates
1	Brown Top Millet	50	April 1 to August 15
2	Rye Grain	55	August 16 to March 31
	Annual Rye Grass ¹	15	
¹ The use of Italian Rye Grass is prohibited.			

3.3 GROUND PREPARATION

- A. Bring all areas to proper line, grade and cross section indicated on the plans.
- B. Repair erosion damage prior to commencing seeding operations.
- C. Loosen seedbed to minimum depth of 3".
- D. Remove all roots, clods, stones larger than 1" in any dimension, and other debris.
- E. Provide and prepare topsoil in accordance with Section 02310.
- F. Conduct soil test to determine pH factor.
 - 1. If pH is not in the range of 6.0 to 6.5, adjust.

3.4 APPLICATION OF FERTILIZER

- A. Spread uniformly over areas to be seeded at:
 - 1. Rate of 1000 lbs. per acre.

2. Fertilize centipede at the application rate of 20 pounds per acre of 16-4-8 or 15-0-15.
 3. Use approved mechanical spreaders.
- B. Mix with soil to depth of approximately 3".

3.5 SOWING METHODS

- A. General:
1. Perform seeding during the periods and at the rates specified in the seeding schedules.
 2. Do not conduct seeding work when ground is frozen or excessively wet.
 3. Produce satisfactory stand of grass regardless of period of the year the work is performed.
- B. Seeding, slopes less than four horizontal to one vertical:
1. Shall conform to Methods EA, WF or WCF as specified hereinafter.
 2. Method EA (Emulsified Asphalt):
 - a. Sow seed not more than 24 hours after application of fertilizer.
 - b. Use mechanical seed drills on accessible areas, rotary hand seeders, power sprayers, etc. may be used on steep slopes or areas not accessible to seed drills.
 - c. Cover seed and lightly compact with cultipacker if seed drill does not.
 - d. Within 24 hours following compaction of seeded areas, uniformly apply 0.2 gallons per square yard of emulsified asphalt over the seeded area.
 3. Method WF
 - a. Sow seed as specified for Method EA.
 - b. Within 24 hours following covering of seeds, uniformly apply excelsior fiber at the rate of 100 lbs. per 1000 sq.ft.
 - c. Apply material hydraulically.
 - d. Seeded areas to be lightly rolled to form a tight mat of the excelsior fibers.
 4. Method WCF
 - a. Apply seed, fertilizer and wood fiber mulch using hydraulic equipment.
 - b. Equipment to have built-in agitation system with capacity to agitate, suspend and homogenously mix a slurry of the specified amount of fiber, fertilizer, seed and water.
 - c. Minimum capacity of slurry tank: 1000 gallons.
 - d. Apply fiber mulch at rate of 35 lbs. per 1000 sq.ft.
 - e. Regulate slurry mixture so that amounts and rates of application will result in uniform application of all materials at not less than the specified amounts.

- f. Apply slurry in a sweeping motion, in an arched stream, so as to fall like rain, allowing the wood fibers to build upon each other.
 - g. Use color of wood pulp as guide, spraying the prepared seedbed until a uniform visible coat is obtained.
- C.
 - 1. Seeding (slopes greater than four horizontal to one vertical)
 - 2. Sow seed as specified for Method EA, unmulched.
 - 3. Cover seeded area with erosion control blanket.

3.6 SECOND APPLICATION OF FERTILIZER

- A. When plants are established and showing satisfactory growth, apply nitrogen at the rate of 1.0 lb. per 1000 sq.ft.
- B. Apply in dry form unless otherwise directed by the Engineer.
- C. Do not apply to stands of temporary grasses.

3.7 MAINTENANCE

- A. Maintain all seeded areas in satisfactory condition until final acceptance of the work.
- B. Areas not showing satisfactory evidence of germination within six weeks of the seeding date shall be immediately reseeded, fertilized and/or mulched.
- C. Repair any eroded areas.
- D. Mow as necessary to maintain healthy growth rate until final acceptance of the work.

3.8 ACCEPTANCE

- A. Permanently seeded areas will be accepted when the grass attains a height of 2".
- B. No acceptance will be made of temporary seeded areas. Rework and seed per Permanent Seeding Schedule.

END OF SECTION

SECTION 03250

CONCRETE SPECIALTY ITEMS

PART 1. GENERAL

1.1 DESCRIPTION

- A. Work included: Provide all labor and materials necessary to provide and install concrete accessories, specialties, and related materials as needed for a complete and proper installation.
- B. Related work:
 - 1. Documents affecting work of this section include, but are not necessarily limited to, General Conditions, Supplementary Conditions, and sections in Division 1 of these specifications.
 - 2. Section 03300 - Cast-in-Place Concrete.
 - 3. Section 03600 - Non-Shrink Grout.
 - 4. Section 05990 - Miscellaneous Metals.
 - 5. Section 07920 - Sealants and Caulking.

1.2 QUALITY ASSURANCE

- A. Use adequate numbers of skilled workmen who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the work of this section.
- B. Follow the manufacturer's instructions for preparation and use of proprietary items.

1.3 SUBMITTALS

- A. Comply with the pertinent provisions of Section 01340.
- B. Within 30 calendar days after the Contractor has received the Owner's Notice to Proceed, submit manufacturer's literature, including a statement of compliance with any referenced standards and any manufacturer's instructions for use as may be necessary.

PART 2. PRODUCTS

2.1 PREMOLDED JOINT FILLERS

- A. In concrete pavements (exterior) and concrete sidewalks, use asphalt impregnated cellulose fiber joint fillers complying with ASTM D1751.
- B. In all other concrete structures use self-expanding cork joint fillers complying with ASTM D1752, Type III.

2.2 NEOPRENE BEARING PADS

- A. Use bearing pads composed of high quality elastomeric neoprene with a hardness of 50 durometer unless otherwise indicated on the Drawings. Thickness and size shall be as shown on the drawings.

2.3 ANCHORING AND BONDING MATERIALS

- A. Epoxy adhesive: Use a two component, solvent free moisture-insensitive, high modulus, high strength epoxy adhesive conforming to ASTM C881.
 - 1. Provide Sikadur 32 Hi-Mod by Sika Corporation, Epobond by L&M Construction Chemicals, Inc., Bond-1 by Permagine Industries, Inc. or approved equal.
 - 2. Mix epoxy components with clean sand fine aggregate conforming with ASTM C33 as recommended by the epoxy manufacturer when required by the use intended.
- B. Bonding agents: Use polyvinyl acetate homopolymer liquid bonding agent.
 - 1. Use Weld Crete by Larsen; or
 - 2. Everweld by L&M Construction Chemicals, Inc.; or
 - 3. Approved equal.
- C. Bonding admixtures: Use acrylic latex or acrylic polymer liquid bonding admixtures.
 - 1. Use Acryl 60 by Thoro System Products; or
 - 2. Everbond by L&M Construction Chemicals, Inc.; or
 - 3. Sikabond by Sika Corporation; or
 - 4. Approved equal.
 - 5. Mix in accordance with manufacturer’s instructions.

2.4 CONCRETE SEALER

- A. Where concrete sealer is indicated on the drawings, provide a penetrating alkyl polymer silane sealer.

Minimum active material content	Minimum water repellency rating (ASTM C67)
0.2	0.99

- B. Use Pentane by L&M Construction Chemicals, Inc., Dri Sil 20 by Dow Corning Corporation, Sil-Act ATS22 by Advanced Chemical Technologies or approved equal.

2.5 OTHER MATERIALS

- A. Provide other materials, not specifically described but required for a complete and proper installation, as selected by the Contractor subject to the approval of the Engineer.

PART 3. EXECUTION

3.1 PREMOLDED JOINT FILLERS

- A. Install joint fillers in accordance with the manufacturer's recommendations.
 - 1. Fasten the joint filler to previously cast concrete using compatible adhesives.
 - 2. Precut joint fillers to fit snugly against any waterstop if present.
 - 3. Tape butt splices to prevent the intrusion of concrete into the joint.
 - 4. Precut joint filler as necessary to provide enough recess to accommodate any required sealants and backer rod.

3.2 CONCRETE SEALER

- A. Preparation: Remove all surface dirt, oils, dust and other contaminants from the surface to be sealed and leave it clean and dry.
- B. Apply the sealer in accordance with the manufacturer's directions.
 - 1. Do not dilute or thin the sealer.
 - 2. Apply by brush, spray or roller.
 - 3. Apply at a rate of 100 sq.ft. to 125 sq.ft. per gallon.

3.3 OTHER MATERIALS

- A. Mix, place, apply or install all other proprietary materials in strict accordance with the manufacturer's directions.

3.4 MEASUREMENT AND PAYMENT

- A. No measurement or direct payment will be made for the work under this Section and all costs for same shall be included in the price bid for the item to which it pertains.

END OF SECTION

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SECTION 03300

CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Work Included: Provide cast-in-place concrete, including formwork and reinforcement, where shown on the drawings, as specified herein, and as needed for a complete and proper installation.
- B. Related Work:
 - 1. Documents affecting work of this section include, but are not necessarily limited to, General Conditions, Supplementary Conditions, and sections in Division 1 of these specifications.

1.2 QUALITY ASSURANCE

- A. Use adequate numbers of skilled workmen who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the work of this section.
- B. Reference Standards: Comply with the following codes, specifications and standards, except as otherwise shown or specified:
 - 1. American Concrete Institute (ACI) Publications:
 - a. ACI 301 Specification for Structural Concrete for Buildings
 - b. ACI 305 Recommended Practice for Hot Weather Concreting
 - c. ACI 306 Recommended Practice for Cold Weather Concreting
 - d. ACI 315 Manual of Standard Practice for Detailing Reinforced Concrete Structures
 - e. ACI 318 Building Code Requirements for Reinforced Concrete
 - f. ACI 347 Recommended Practice for Concrete Framework
 - 2. American Society for Testing and Materials (ASTM) Publications:
 - a. A185 Welded Steel Wire Fabric for Concrete Reinforcement
 - b. A615 Deformed and Plain Billet Steel Bars for Concrete Reinforcement
 - c. C31 Making and Curing Concrete Test Specimens in the Field
 - d. C33 Concrete Aggregates
 - e. C39 Compressive Strength of Cylindrical Concrete Specimens
 - f. C94 Ready-Mixed Concrete
 - g. C150 Portland Cement
 - h. C260 Air-Entraining Admixtures for Concrete
 - 3. Concrete Reinforcing Steel Institute (CRSI):

- a. "Manual of Standard Practice"
- 4. American Welding Society (AWS) Publication
 - a. D12.1-61 Welding Reinforcement Steel, Metal Inserts and Connections in Reinforced Concrete
- C. Testing Agency: A testing laboratory will be retained by the Owner to perform material evaluation tests required by these specifications.
- D. Qualifications of contractors performing concrete work: Minimum of two (2) years experience on comparable concrete projects.
- E. Plant Qualification: Plant equipment and facilities shall meet all requirements of the Check List for Certification of Ready Mixed Concrete Production Facilities of the National Ready Mixed Concrete Association and ASTM C94.

1.3 SUBMITTALS

- A. Comply with the pertinent provisions of Section 01340.
- B. Proportions of proposed mix shall be determined by means of laboratory tests of concrete made with the cement and aggregate proposed for use.
- C. Provide report in detail from an approved testing laboratory showing 7-day and 28-day strengths obtained using materials proposed.
- D. Required average strength above specified strength:
 - 1. Determinations of required average strength above specified strength (f'c) shall be in accordance with ACI 318 and ACI 301.
 - 2. Establish the required average strength of the design mix using the materials proposed to be employed. Standard deviations shall be determined by thirty tests. Average strength used for selecting proportions shall exceed specified strength (f'c) by at least:

400 psi	Standard deviation is less than 300
550 psi	Standard deviation is 300 to 400
700 psi	Standard deviation is 400 to 500
900 psi	Standard deviation is 500 to 600
1200 psi	Standard deviation is above 600 or unknown

- 3. When the ready-mix producer does not have a record of past performance, the combination of materials and the proportions selected shall be selected from trial mixes having proportions and consistencies suitable for the work using at least three (3) different water/cement ratios which will produce a range of strengths encompassing those required. Average strength required shall be 1200 psi above specified strength.
- 4. Cost of this work shall be borne by the Contractor.

- E. Manufacturer's Data: Submit manufacturer's specification with application instructions for proprietary materials and items, including curing compound, form release agents, admixtures, patching compounds, and others as required by the Engineer.
- F. Shop drawings: Submit the following shop drawings to the Engineer for approval before work is started.
 - 1. Reinforcing Steel Drawings: Prepare in accordance with ACI 315. Indicate bending diagrams, assembly diagrams, splicing and laps of bars, dimensions and details of bar reinforcing and accessories.

1.4 PRODUCT HANDLING

- A. Comply with pertinent provisions of Section 01640.
- B. Store reinforcement in a manner that will avoid excessive rusting or coating by grease, oil, dirt and other objectionable materials.
- C. Keep reinforcement in separate piles or racks so as to avoid loss of identification after bundles are broken.

PART 2 - PRODUCTS

2.1 FORMS

- A. Use form materials conforming to ACI 347.
- B. Form Lumber: Use lumber of sufficient quality and grade, size and stiffness to adequately support the work and ensure dimensional accuracy.
- C. Form Ties: Use form ties which do not leave an open hole through the concrete and which permit neat and solid patching at every hole.
 - 1. Use ties with cones that allow a 1" break back and facilitate patching.
 - 2. On structures containing water or other liquid or below grade structures, use embedded rod ties with integral water stops in addition to cones.
 - 3. Wire ties and wood spreaders will not be permitted.
- D. Form Coatings: Form release coating shall be neat oil with surface wetting agent or chemical release agent which effectively prevents absorption of moisture, prevents bonding with concrete, is non-staining to concrete and leaves the concrete with a paintable surface.
 - 1. On surfaces to receive an applied coating, use a residual free chemical form release agent which is compatible with the applied coating and will not prevent the applied finish from satisfactorily bonding to the concrete.
- E. Chamfer Strips: Chamfer strips shall be wood or polyvinyl strips or approved equal, designed to be nailed in the forms to provide a 3/4" chamfer (unless indicated otherwise) at all exposed edges and corners of concrete members.

2.2 REINFORCEMENT

A. Comply with the following as minimums:

1. Bars: ASTM A615, Grade 60, unless otherwise shown on the drawings, using deformed bars for Number 3 and larger.
2. Welded Wire Fabric: ASTM A185.
 - a. Use sheet (mat) welded wire fabric only.
 - b. Welded wire fabric supplied in rolls will not be accepted.
3. Bending: ACI 315 and ACI 318.

Fabricate reinforcement to the required shapes and dimensions, within fabrication tolerances stated in the CRSI "Manual of Standard Practices".

Do not use reinforcement having any of the following defects:

1. Bar lengths, depths, or bends exceeding the specified fabricating tolerances.
2. Bends or kinks not indicated on the drawings or required for this work.
3. Bars with excessive rust, scale, dirt, oil or other defects which will reduce the bond or the effective cross section of the bar.

Furnish all support bars, tie bars, chairs, bolsters, etc. required for properly supporting and spacing bars in the forms.

1. For slabs on grade, use supports with stand plates or horizontal runners where wetted base materials will not support chair legs. Other supports must be approved by the Engineer.
2. For exposed-to-view concrete surfaces, where legs of supports are in contact with forms, provide supports with legs which are hot-dip galvanized, plastic protected or stainless steel.
3. Supply supports for welded wire fabric as follows:

Welded Wire Reinforcement (diameter)	Welded Wire Spacing (inches)	Maximum Support Spacing (feet)
W9 or larger	12 and greater	4
W5 to W8	12 and greater	3
W9 and larger	Less than 12	3
W4 to W8	Less than 12	2
Less than W4	Less than 12	1.5

Tie Wire: FS QQ-W-461, annealed steel, black, 16 gauge minimum.

Welding Electrodes: AWS A5.1, low hydrogen, E70 series.

Splice Devices: Shall be sized to develop one hundred twenty-five (125%) percent of yield strength of bar.

2.3 CONCRETE MATERIALS

- A. Cement: Use Portland Cement: ASTM C150, Type I, Type I-P or Type II, low alkali.
 - 1. Where concrete will be exposed to sewage, use Type II or I-P cement.
 - 2. Fly ash shall conform to ASTM C618, Class C or F.
 - 3. Fly ash content shall not exceed 20% by weight of the total amount of cementations materials (Portland cement plus fly ash).
- B. Aggregates:
 - 1. Fine Aggregate: Conform to ASTM C33.
 - 2. Coarse Aggregate: Conform to ASTM C33, Size #57.
- C. Water: Clean and potable and free from injurious amounts of deleterious materials.
- D. Admixtures
 - 1. Air entraining admixture: ASTM C260.
 - 2. Water reducing, set controlling admixture: Conform to ASTM C494.
 - a. Type A - water reducing.
 - b. Type D - water reducing and retarding.
 - 3. Superplasticizers: Conform to ASTM C494, Types F and G.
 - a. Use superplasticizers in thin section placements and in areas of congested reinforcing and/or embedded items, or where otherwise approved by the Engineer.
 - b. Use where conventional consolidation techniques are impractical.
 - 4. Do not use admixtures containing calcium chloride.
- E. Fiber Reinforcing
 - 1. Use fiber reinforcing where indicated on the drawings.
 - 2. Provide polypropylene or co-polymer fibers as manufactured by High Tech Fibers, Inc., Fibermesh Company or an approved equal.

3. Where required, use fiber reinforcing at a rate of 2.0 lbs. per cubic yard unless another rate is indicated on the drawings.

F. Curing Compounds

1. On all vertical and formed surfaces, construction joints, basin slabs, surfaces to receive an applied coating or finish, and other surfaces except as otherwise indicated or specified, use a non-residual, non-staining curing compound conforming to ASTM C309 Type 1 and 1D. Acceptable products are:
 - a. L&M Cure by L&M Construction Chemicals, Inc.
 - b. Horn WB-75 by A.C. Horn Company.
 - c. Sonosil by Sonneborn, Inc.
 - d. Approved equal.
2. On building floor slabs not otherwise receiving an applied coating or finish and on other flatwork as indicated on the Drawings, provide an acrylic copolymer curing and sealing compound conforming to ASTM C309 Type 1 and the following:
 - a. Non-yellowing.
 - b. Minimum 20% solids.
 - c. Maximum unit moisture loss in accordance with ASTM C156 - 0.40 kg./sq.m at 72 hours.
 - d. Acceptable products are Dress & Seal by L&M Construction Chemicals, Inc., Clear Seal Standard by A. C. Horn Company, Kure-N-Seal 0800 by Sonneborn, Inc., or approved equal.

2.4 CONCRETE MIXES

- A. Provide concrete with the compressive strengths shown on the drawings. When such strengths are not shown on the drawings, provide the following 28-day strengths as minimum:

All structural concrete except as indicated in Nos. 2 and 3 below:	4000 psi
All sidewalks, curbs and gutters, and unreinforced foundations:	3000 psi
Thrust blocking, backfill or encasement for piping, and concrete fill:	2500 psi
Prestressed or precast concrete:	5000 psi

- B. Maximum Water Cement Ratios

4000 psi concrete	0.5
3000 psi concrete	0.53
2500 psi concrete	0.67

C. Entrained Air

3000 and 4000 psi concrete	5% ± 1%
2500 psi concrete	Not Required

D. Slump

3000 and 4000 psi concrete	4" ± 1"
2500 psi concrete	5" ± 1"

E. Production of Concrete

1. General: Concrete shall be ready mixed and shall be batched, mixed and transported in accordance with ASTM C94 except as otherwise indicated.
2. Monitor time and mix proportions by plant delivery slips.
3. Air Entraining Admixtures: Add air-entraining admixture into the mixture as a solution and measure by means of an approved mechanical dispensing device.
4. Water reducing and retarding admixture: Add water reducing and retarding admixture and measure as recommended by the manufacturer.
5. Addition of water to the mix upon arrival at the job site shall not exceed that necessary to compensate for a 1" loss in slump, nor shall the design maximum water-cement ratio be exceeded. Water shall not be added to the batch at any later time.
6. Weather Conditions: Control temperature of mix as required by ACI 306 "Cold Weather Concreting" and by ACI 305 "Hot Weather Concreting".

PART 3 - EXECUTION

3.1 SURFACE CONDITIONS

- A. Examine the areas and conditions under which work of this Section will be performed. Correct conditions detrimental to timely and proper completion of the Work. Do not proceed until unsatisfactory conditions are corrected.
- B. Water, mud, organic, and other detrimental material shall be removed from excavations before concrete is deposited.
- C. Notify the Engineer prior to placing concrete and place no concrete until the formwork, reinforcing and embedded items have been inspected by the Engineer.

3.2 FORMWORK

- A. General
 1. Construct forms in conformance with ACI 347.

2. Design, erect, support, brace and maintain formwork so it will safely support vertical and lateral loads which might be applied until such loads can be supported safely by the concrete structure.
3. Construct forms to the exact sizes, shapes, lines and dimensions shown, and as required to obtain accurate alignment, location, grades, level and plumb work in the finished structure.
4. Provide formwork sufficiently tight to prevent leakage of cement paste during concrete placement. Solidly butt joints and provide backup material at joints as required to prevent leakage and prevent fins.

B. Form Construction and Erection

1. Construct forms in conformance with ACI 347.
2. Provide for openings, offsets, keyways, recesses, moldings, reglets, chamfers, blocking, screeds, bulkheads, anchorages, inserts and other embedded items as required.
3. Hold inner and outer forms for vertical concrete together with combination steel ties and spreaders approved by the Engineer.
4. Unless specifically stated otherwise, provide 3/4" chamfer at all exposed edges of concrete.
5. Provide temporary openings in the formwork where necessary to facilitate cleaning and inspection of the formwork.
6. Coat form contact surfaces with approved form coating compound prior to placing reinforcing steel.
7. Do not allow excess form coating material to accumulate in the forms or to come in contact with reinforcing surfaces which will bond to fresh concrete.
8. Side forms for footings may be omitted, and concrete may be placed directly against excavation only when requested by the Contractor and approved by the Engineer.
9. Provide a positive means of adjustment of shores and struts and insure that all settlement is taken up during concrete placing.
10. Construct blockouts and formed openings of sufficient size and proper location to permit final alignment of items within it or passing through it.
 - a. Allow sufficient space for grouting, packing or sealing around any items penetrating the opening as may be required to ensure watertightness.
 - b. Provide openings with continuous keyways with waterstops where required, and provide a slight flare to facilitate grouting and the escape of entrapped air during grouting.

- c. Provide only blockouts or openings that are shown on the drawings or otherwise approved by the Engineer.
- C. Formwork Reuse: Reuse only forms that are in good condition and which maintain a uniform surface texture on expose concrete surfaces.
 1. Apply a light sanding as necessary to obtain a uniform texture.
 2. Plug unused tie holes and penetrations flush with the form surface.
- D. Removal of Forms
 1. Do not disturb or remove forms until the concrete has hardened sufficiently to permit form removal with complete safety. Do not remove shoring until the member has acquired sufficient strength to support its own weight, the load upon it, and the added load of construction.
 2. Do not remove forms before the following minimum times without prior approval from the Engineer:
 - a. Sides of footings or slabs on grade 24 hrs
 - b. Walls not supporting load 48 hrs
 - c. Vertical sides of beams 48 hrs
 - d. Columns not supporting load 48 hrs
 - e. Suspended slabs or beam bottoms (forms only) 10 days
 3. In determining the minimum stripping times, consider only the cumulative time during which the ambient temperature of the air surrounding the concrete is above 50°.
 4. Do not remove shoring for suspended slabs or beams until the concrete has reached 75% of the specified 28-day strength.
 5. When reshoring or backshoring is permitted or required, plan the operations in advance and submit procedures to the Engineer for approval.
 - a. Design and plan all reshoring operations to support all construction loading and in accordance with ACI 347.
 6. Exercise care in removing forms from finished concrete surfaces so that surfaces are not marred or gouged and that corners are true, sharp and unbroken.
 7. Do not permit steel spreaders, form ties, or other metal to project from or be visible on any concrete surface except where so shown on the drawings.
 8. Whenever the formwork is removed during the curing period, continue to cure the exposed concrete by one of the methods specified herein.

3.3 EMBEDDED ITEMS

- A. Embedded Items: Set anchor bolts and other embedded items accurately and securely in position in the forms until the concrete is placed and set.
 - 1. Use templates where practical for all anchor bolts.
 - 2. Check locations of all anchor bolt and special castings prior to placing concrete and verify locations after concreting.
- B. Piping Cast in Concrete
 - 1. Install and secure sleeves, wall pipes and pipe penetrations before placing concrete.
 - 2. Do not weld or otherwise attach piping to reinforcing steel.
 - 3. Support piping to be encased in concrete securely and on firm foundation so as to prevent movement or settlement during concreting.
- C. Locate electrical conduit so that it will not impair the strength of the construction.
 - 1. Do not use conduits running within (not passing through) a slab, wall or beam that are larger in outside diameter than $1/2$ " the overall concrete thickness unless otherwise approved by the Engineer.
 - 2. Do not space conduits closer than three conduit diameters apart unless otherwise approved by the Engineer.

3.4 REINFORCEMENT

- A. General: Comply with the specified codes and standards and Concrete Reinforcing Steel Institute's recommended practice for "Placing Reinforcing Bars" for details and methods of reinforcement placement and supports and as herein specified.
 - 1. Clean reinforcement and remove loose dust and mill scale, earth, and other materials which reduce or destroy bond with concrete.
 - 2. Position and secure reinforcement against displacement by forms, construction, and the concrete placement operations.
 - 3. Use adequate number of ties to secure reinforcing.
 - 4. Do not weld or field bend reinforcing without prior approval by the Engineer.
- B. Placing Reinforcing
 - 1. Provide and install all chairs, runners, bolsters, standees and other accessories in sufficient quantities to satisfactorily position the reinforcing and hold it in place during concrete placement.
 - 2. Support reinforcing for slabs on ground on chairs or bolsters with stand plates or a properly sized concrete cube.

- a. Use concrete bricks as supports only as approved by the Engineer.
 3. Secure and tie dowels in place prior to placing concrete. Do not press dowels into wet concrete.
- C. Concrete Cover: Unless otherwise indicated on the drawings or specified herein, install reinforcing with clear concrete coverage in conformance with ACI 318.
1. All reinforcement, regardless of size, exposed to water or sewage shall have 2" cover.
 2. Place reinforcement a minimum of 2" clear of any openings or metal pipe or fittings.
- D. Splicing Reinforcement: Splice reinforcement steel in accordance with the latest revisions of ACI 318 "Building Code Requirements for Reinforced Concrete" unless shown otherwise on the drawings.
1. All splices at wall corners or intersections and at wall and foundation intersections shall be Class B tension splices.
 2. All other splices of vertical or horizontal steel in walls shall be Class B tension splices as per ACI 318.
 3. Horizontal ring steel in circular, non-prestressed concrete tanks shall be Class B tension splices and the splices shall be staggered so that no more than 50% of the bars are spliced at any one location.
 4. All welded or mechanical splicing devices shall develop 125% of the yield strength of the bar.
 5. Column vertical bars shall lap 30 bar diameters with dowels at the base of the column unless otherwise noted. Dowels shall be the same size and quantity as column vertical bars unless otherwise noted.
 6. All splices not otherwise shown or specified shall be Class B tension lap splices.
- E. Tolerances: Place bars in the locations indicated within the tolerances conforming to the CRSI "Manual of Standard Practice".
- F. Welded Wire Mesh: Install welded wire fabric in as long of a length as practicable and lay flat before placing concrete.
1. Use only mat welded wire fabric. Do not use welded wire fabric from rolls.
 2. Support and tie mesh to prevent movement during concrete placement.
 3. Lap adjoining pieces at least one full mesh and lace splices with wire.
 4. Provide, at a minimum, supports for welded wire fabric according to the Table in Section 2.2.D.3. Confirm the adequacy of the support spacings listed therein for

the anticipated construction loads. Increase the number of supports, if necessary, to assure that the final position of the welded wire fabric will conform to that shown on the drawings.

5. Do not place welded wire fabric on the subbase surface and then hook or "pull up" the reinforcement during concrete placement.
6. Do not lay welded wire fabric on top of the freshly placed concrete and then "walk it" into place.

3.5 PLACING CONCRETE

A. Preparation

1. Remove foreign matter accumulated in the forms.
2. Rigidly close openings left in the formwork.
3. Wet wood forms sufficiently to tighten up cracks. Wet other material sufficiently to maintain workability of the concrete.
4. Use only clean tools.
5. Provide and maintain sufficient tools and equipment on hand to facilitate uninterrupted placement of the concrete.
6. Before commencing concrete, inspect and complete installation of formwork, reinforcing steel and all items to be embedded or cast-in.

B. Conveying

1. Transport and handle concrete from the truck to the place of final deposit as rapidly as practicable by methods which will prevent segregation or loss of ingredients to maintain the quality of the concrete.
2. Provide equipment for lifting, dumping, chuting, pumping or conveying the concrete, of such size and design as to insure a practically continuous flow of concrete at the delivery and without separation of materials.
3. Use hoppers and elephant trunks where necessary to prevent the free fall of concrete for more than 8'.
4. Do not use concrete that is not placed within 1 1/2 hours after water is first introduced into the mix unless the slump is such that it meets the specified limits without the addition of water to the batch.

C. Placing

1. Deposit concrete as nearly as practicable in its final location so as to avoid separation due to rehandling and flowing.
2. Deposit concrete in horizontal layers not deeper than 2', avoiding inclined layers.
3. Place concrete at such a manner that concrete upon which fresh concrete is deposited is still plastic.
4. Bring slab surfaces to the correct level with screeds set to the proper elevation.

- D. Hot Weather Placement: Place concrete in hot weather in accordance with ACI 305 "Hot Weather Concreting" and as specified herein.
 - 1. Do not place concrete whose temperature exceeds 100°F.
 - 2. Thoroughly wet forms and reinforcing prior to placement of concrete.
 - 3. Use additional set retarder as necessary to increase set time.
 - 4. Limit the size of the pour where it may reduce the likelihood of cold joints due to reduced set time.
 - 5. Shade the fresh concrete as soon as possible after placing.
 - 6. Start curing as soon as the concrete is sufficiently hard to permit without damage.
- E. Cold Weather Placement: Place concrete in cold weather in accordance with ACI 306 and as specified herein.
 - 1. Except when authorized specifically by the Engineer, do not place concrete when the atmospheric temperature is below 40°F.
 - 2. When cold weather placement is approved by the Engineer, heat either the mixing water or aggregate or both so that the concrete temperature is between 65°F and 85°F.
 - 3. Protect the freshly placed concrete by adequate housing or covering and provide heat to maintain a temperature of not less than 50°F for not less than four days.
 - 4. Do not add salts, chemicals, or other materials to the concrete mix to lower the freezing point of the concrete.
- F. Consolidation
 - 1. Consolidate each layer of concrete immediately after placing, by use of internal concrete vibrators supplemented by hand spading, rodding, or tamping.
 - a. Use vibrators having a 2" head diameter and a minimum frequency of 8000 vibrations per second.
 - b. Provide sufficient number of vibrators to properly consolidate the concrete, keeping up with placement operations.
 - c. Provide at least one spare vibrator on site.
 - 2. Insert and withdraw vibrators at points approximately 18" apart.
 - 3. Do not vibrate forms or reinforcement.
 - 4. Do not use vibrators to transport concrete inside the forms.

3.6 PROTECTION

- A. Protect the surface finish of newly placed concrete from damage by rainwater or construction traffic.
- B. Do not apply design loads to structures until the concrete has obtained the specified strength.

1. Do not backfill against walls until they have reached the specified strength and all supporting or bracing walls, slabs, etc. have also reached the specified strength, unless otherwise permitted by the Engineer.
2. Protect structures from construction overloads.

3.7 CURING

- A. Beginning immediately after placement, protect concrete from premature drying, excessively hot and cold temperatures and mechanical injury.
- B. Continuously cure concrete for a period of not less than 7 days after placement.
 1. When seven-day cylinder breaks indicate, in the opinion of the Engineer, the possibility of low strength concrete, provide additional curing as per the request of the Engineer.
 2. When temperatures during the curing period fall below 40°F, provide additional curing time as directed by the Engineer.
- C. Unless otherwise directed by the Engineer, cure concrete not in contact with forms in accordance with one of the following procedures:
 1. Ponding or Sprinkling: Keep entire concrete surface wet by continuously sprinkling or by allowing water to pond, covering all surfaces.
 2. Wet Burlap: Thoroughly wet and cover all concrete surfaces with wet burlap mats as soon as the concrete has set sufficiently to avoid marring the surface.
 - a. Keep the burlap continuously wet during the curing period.
 3. Curing Blankets: Thoroughly wet concrete surfaces to be cured and cover with curing blankets as soon as the concrete has set sufficiently to avoid marring the surface.
 - a. Weight the blankets down to maintain close contact with the concrete surface.
 - b. Use sheets of waterproof Kraft paper with the joints between sheets taped continuously; or
 - c. Use sheets of 4 mil or thicker polyethylene with the joints between sheets continuously taped.
 4. Wet Sand: Apply a layer of sand over the entire surface and keep it continuously wet.
 5. Curing Compound: Apply curing compound immediately after completion of the finish on uniformed surfaces and within two hours after removal of forms on formed surfaces.
 - a. Spray the entire surface with two coats of liquid curing compound, applying the second coat in the direction of 90° to the first coat.

- b. Apply compound in accordance with the manufacturer's instructions to cover the surface with a uniform film which will seal thoroughly.
- D. Hot Weather: When necessary, provide wind breaks, shading, fog spraying, sprinkling, ponding or wet covering with a light colored material applying as quickly as concrete hardening and finishing operations will allow.

3.8 CONCRETE FINISHING

- A. Finish Schedule: Unless otherwise indicated on the drawings, finish all concrete surfaces in accordance with the following schedule:
 - 1. Form Finish: Formed surfaces not ordinarily exposed to view, including:
 - a. Interior walls of open tanks below a line one foot lower than the lowest normal water level.
 - b. The underside of slabs not exposed to view.
 - c. Walls below grade.
 - 2. Cementations Coating: All formed surfaces exposed to view including:
 - a. Interior walls of tanks above a line one foot lower than the lowest normal water level.
 - b. The underside of slabs, soffits, etc. exposed to view.
 - 3. Float Finish: Slab surfaces not exposed to view or not receiving an applied thin finish, including:
 - a. Bottom slabs of tanks or structures containing water sewage or other liquid.
 - b. Foundations not exposed to view.
 - c. Roof slabs to be covered with insulation and/or built-up roofing.
 - 4. Trowel Finish: Interior slab surfaces exposed to view or to receive an applied thin film coating or floor finish, including:
 - a. Interior, indoor slabs and floors of buildings.
 - b. Surfaces on which mechanical equipment moves.
 - c. Floors receiving vinyl tile, resilient flooring, carpet, paint, etc.
 - 5. Broom Finish: Exterior, outdoor slabs exposed to view including:
 - a. Outdoor floor slabs and walkways.
 - b. Other floors which may become wet or otherwise require a non-skid surface.
 - c. Sidewalks and concrete pavements.

6. Scratch Finish: Surfaces which are to receive a thick topping or additional concrete cast against them including:
 - a. Surfaces receiving concrete equipment pads.
 - b. Floors receiving concrete topping.
 - c. Construction joints not otherwise keyed.

7. Edge Finish: Exposed edges of slabs not receiving chamfer including:
 - a. Sidewalk edges and joints.
 - b. Pavement edges and joints.
 - c. Other slab edges not chamfered.

B. Finishing Procedures

1. Form Finish

- a. Repair defective concrete.
- b. Fill depressions deeper than 1/2".
- c. Fill tie holes.
- d. Remove fins exceeding 1/2" in height.

2. Cementations Finish

- a. Patch all tie holes and defects and remove all fins.
- b. Within one day of form removal, fill all bug holes, wet the surfaces and rub with carborundum brick until a uniform color and texture are produced; or
- c. Dampen surfaces, brush apply a grout slurry consisting of 1 part portland cement to 11/2 parts sand, and rub the surface vigorously with a stone. Remove all excess grout.
- d. Provide a two coat cement base waterproofing, sealing finish of Thoroseal and Thoroseal Plaster Mix as manufactured by Standard Dry Wall Products, Inc. or an approved equal.

- (1) Patch all tie holes and defects and removal all fins, and clean surface of all dirt, laitance, grease, form treatments, curing compounds, etc.
- (2) Key coat: Apply key coat of Thoroseal at a rate of two (2) lbs. per sq.yd. by fiber brush. Mix material using one part of Acryl 60 to three parts clean water. Should material start to drag during application, dampen surface with water. During hot weather periods, dampen surfaces with water prior to application of key coat material. Key coat shall be allowed to cure for five (5) days before applying finish coat.
- (3) Apply a finish coat consisting of a four (4) to six (6) lbs. per sq.yd. application of Thoroseal Plaster Mix using steel trowel or spray gun. Color shall be pearl gray unless otherwise noted. Mix dry material using one (1) part Acryl 60 to three (3) parts clean water. Firmly press the mix into all voids and level with a steel trowel.

When surface is set so that it will not roll or lift, float it uniformly using a sponge float.

3. Float Finish
 - a. Begin floating when the water sheen has disappeared and when the surface has stiffened sufficiently to permit the operation.
 - b. Cut down all high spots and fill all low spots and float the slab to a uniform sandy texture.
4. Trowel Finish
 - a. Float finish as specified herein.
 - b. Power trowel to a smooth surface free of defects.
 - c. After the surface has hardened sufficiently, hand trowel until a ringing sound is produced as the trowel is moved over the concrete surface.
5. Broom Finish
 - a. Float finish as specified herein.
 - b. Provide a scored texture by drawing a broom across the surface.
6. Scratch Surface
 - a. Screed the surface to the proper elevations.
 - b. Roughen with rakes or stiff brushes.
7. Edge Finish: Tool slab edges and joints with a 3/8" radius edging tool.

3.9 SURFACE REPAIR

- A. Patching Mortar
 1. Make a patching mortar consisting of 1 part portland cement to 2 1/2 parts sand by damp loose volume.
 2. Mix the mortar using one part acrylic bonding admixture to two parts water.
- B. Tie Holes: Clean and dampen all tie holes and fill solidly with patching mortar.
- C. Surface Defects
 1. Remove all defective concrete down to sound solid concrete.
 2. Chip edges perpendicular to the concrete surface or slightly undercut, allowing no feather edges.
 3. Dampen surfaces to be patched.

4. Patch defects by filling solidly with repair mortar.
- D. Allow the Engineer to inspect the work before placing the patching mortar.
 - E. Repair defective areas greater than 1 sq.ft. or deeper than 1 1/2" as directed by the Engineer using materials approved by the Engineer at no additional expense to the Owner.

3.10 JOINTS

A. Construction Joints

1. Unless otherwise approved by the Engineer, provide construction joints as shown on the drawings.
2. If additional construction joints are found to be required, secure the Engineer's approval of joint design and location prior to start of concrete placement.
3. Continue all reinforcing across construction joints and provide 1 1/2" deep keyways unless indicated otherwise on the drawings.
 - a. Form keyways in place.
4. Provide water stops in all construction joints of liquid containing structures, structures below grade or other structures as shown on the drawings.

B. Expansion Joints

1. Provide expansion joints of size, type and locations as shown on the drawings.
2. Do not permit reinforcement or other embedded metal items that are being bonded with concrete (except smooth dowels bonded on only one side of the joints, where indicated on the drawings) to extend continuously through any expansion joint.
3. Provide water stops where required.

C. Control or Contraction Joints

1. Locate and construct control and contraction joints in accordance with the drawings.
2. Where no specific joint pattern is indicated in slabs on grade or concrete pavements, submit a proposed joint layout to the Engineer for approval.
3. Where no specific joint details are shown on the drawings, joints may be tooled, preformed or saw-cut.
4. Saw-cut joints as soon as the concrete has hardened sufficiently to prevent aggregates from being dislodged by the saw.

3.11 FIELD QUALITY CONTROL

A. Concrete Cylinder Tests

1. During construction, prepare test cylinders for compressive strength testing, using 6" diameter by 12" long single use molds, complying with ASTM C31.
 - a. Make a set of three test cylinders from each pour of 50 cubic yards or less, plus one additional set of cylinders for each additional 50 cubic yards or fraction thereof.
 - b. Identify each and tag cylinder as to date of pour and location of concrete which it represents.
 - c. Deliver cylinders to testing lab selected by the Owner.
 - d. Cost for preparation and delivery of cylinders shall be borne by the Contractor. Cost for testing cylinders will be borne by the Owner.
2. Should strengths shown by test cylinders fail to meet specified strengths for the concrete represented, then:
 - a. Engineer shall have the right to require changes in the mix proportions as he deems necessary on the remainder of the work.
 - b. Additional curing of those portions of the structure represented by the failed test cylinders shall be accomplished as directed by the Engineer.
 - c. Upon failure of the additional curing to bring the concrete up to specified strength requirements, strengthening or replacement of those portions of the structure shall be as directed by the Engineer.
 - d. The Engineer may require additional testing of concrete in question by either non-destructive methods such as the Swiss Hammer, Windsor Probe or Ultrasonics or by coring and testing the concrete in question in accordance with ASTM C42. Such testing shall be performed at no additional cost to the Owner.

B. Other Field Concrete Tests

1. Slump tests: Either the Engineer or a testing laboratory representative will make slump tests of concrete as it is discharged from the mixer.
 - a. Slump test may be made on any concrete batch at the discretion of the Engineer.
 - b. Failure to meet specified slump requirements (prior to addition of any superplasticizers) will be cause for rejection of the concrete.
2. Temperature: The concrete temperature may be checked at the discretion of the Engineer.

3. Entrained Air: Air content of the concrete will be checked by a representative of the testing laboratory at the discretion of the Engineer.
- C. Coordination of Laboratory Services: The Contractor shall be responsible for coordination of laboratory services.
1. Maintain a log recording quantities of each type of concrete placed, date and location of pour.
 2. Inform the testing laboratory of locations and dates of concrete placement and other information as required to be identified in the laboratory's test reports.
- D. Tests required because of extensive honeycombing, poor consolidation of the concrete or any suspected deficiency in the concrete will be paid for by the Contractor.
- E. Dimensional Tolerances
1. Dimensional tolerances for allowable variations from dimensions or locations of concrete work, including the locations of embedded items shall be as given in ACI 301.
 2. Where anchor bolts or other embedded items are required for equipment installation, comply with the manufacturer's tolerances if more stringent than those stated in ACI 301.
- F. Watertight Concrete
1. All liquid containing structures, basements or pits below grade shall be watertight.
 2. Any visible leakage or seepage shall be repaired as instructed by the Engineer at no expense to the Owner.
 3. Where physical evidence of honeycombing, cold joints or other deficiencies which may impair the watertightness of a structure exists, the Engineer may at his discretion call for leak testing of the structure.
 - a. Fill the structure with water and allow to stand for not less than 48 hours.
 - b. Make repairs on the structure until all visible leaks are sealed and the leakage rate of the water in the structure is less than 0.1% of the volume held in the structure per day.
 - c. The cost of testing and repairs shall be performed at no expense to the Owner.
- G. Concrete which fails to meet strength requirements, dimensional tolerances, watertightness criteria, or is otherwise deficient due to insufficient curing, improper consolidation or physical damage shall be replaced or repaired as instructed by the Engineer at no expense to the Owner.

END OF SECTION

SECTION 03600

NON-SHRINK GROUT

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Work Included: Provide non-shrink grout for structural grouting, equipment bases, etc. as indicated and needed for a complete and proper installation.
- B. Related Work:
 - 1. Documents affecting work of this section include, but are not necessarily limited to, General Conditions, Supplementary Conditions, and sections in Division 1 of these specifications.
 - 2. Other provisions concerning Non-Shrink Grout may also be stated in other sections of these specifications.

1.2 QUALITY ASSURANCE

- A. Use adequate numbers of skilled workmen who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the work of this section.

1.3 SUBMITTALS

- A. Comply with pertinent provisions of Section 01340.

1.4 PRODUCT HANDLING

- A. Comply with pertinent provisions of Section 01640.
- B. Prevent damage to or contamination of non-shrinking grouting materials during delivery, handling and storage.
- C. Deliver grout to site in polyethylene lined paper bags, not larger than one cubic foot in capacity.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Non-Shrink Grout
 - 1. Provide non-metallic, non-shrink grout.
 - 2. Grout shall evidence no shrinkage when tested in the plastic state, in accordance with ASTM C827, or in the hardened state, in accordance with ASTM CRD588.

3. Initial setting shall not occur in less than 60 minutes.
 4. Compressive strength in 24 hours shall not be less than 3000 psi, when tested in accordance with ASTM C109.
 5. Acceptable Products: U.S. Grout Corporation's Five Star Grout; Sonneborn's SonogROUT; W.R. Bonsal Company's Type A Construction Grout; or equal.
- B. Water: Potable grade.
- C. Gravel: Comply with ASTM C33 for coarse aggregate graded so that 90% passes 3/8" sieve and 90% is retained by No. 4 sieve.

2.2 MIXES

- A. Less than 2" clearance or for difficult grouting locations mix shall consist of grout material and water.
- B. Greater than 2" clearance where coarse aggregate will not obstruct free passage, extend grout by adding ½ pound of gravel to one pound grout material, except where prohibited by manufacturer's recommendations.
- C. Use the minimum amount of water necessary to produce a flowable grout without causing segregation or bleeding.

2.3 MIXING

- A. Mix non-shrink grouting material and water in a mechanical mixing for no less than 3 minutes, unless otherwise approved by the Engineer.
- B. Mix as close to work area as possible and transport the mixture quickly and in a manner that does not permit segregation of materials.
- C. Retempering of grout will not be permitted.

PART 3 - EXECUTION

3.1 FORMWORK

- A. Build leakproof forms that are strong and securely anchored and shored to withstand grout pressures.
- B. Provide ample clearance between formwork and the area to be grouted to permit proper placement of grout.

3.2 SURFACE PREPARATION

- A. Remove all defective concrete, laitance, dirt, oil, grease and other foreign material from concrete surfaces by bush-hammering, chipping, or other similar means, until a sound, clean concrete surface is achieved.

- B. Lightly roughen the concrete, but not enough to interfere with the proper placement of grout.
- C. Remove foreign materials from all steel surfaces in contact with grout.
- D. Align, level, and maintain final positioning of all components to be grouted.
- E. Take special precautions during extreme weather conditions according to the manufacturer's written instructions.
- F. Saturate all concrete surfaces with clean water; remove excess water and leave none standing.

3.2 PLACING

- A. Place non-shrink material quickly and continuously by the most practical means permissible: pouring, pumping or under gravity pressure.
- B. Apply grout from one side only to avoid entrapping air.
- C. Final installation shall be thoroughly compacted and free from air pockets.
- D. Do not vibrate the placed grout mixture or allow it to be placed if the area is being vibrated by nearby equipment.
- E. Do not remove leveling shims for at least 48 hours after grout has been placed.
- F. After shims have been removed, fill voids with plain cement-sand grout.

3.3 CURING

- A. Cure grout for 3 days after placing by keeping wet and covering with curing paper or by another approved method.

END OF SECTION

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SECTION 05990
MISCELLANEOUS METALS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Work included: Provide all miscellaneous metal work as indicated, specified or as needed to provide a complete and proper installation.
- B. Related work:
 - 1. Documents affecting work of this Section include, but are not necessarily limited to, General Conditions, Supplementary Conditions, and Sections in Division 1 of these Specifications.
 - 2. Section 09900 - Painting.

1.2 QUALITY ASSURANCE

- A. Use adequate numbers of skilled workmen who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the work of this Section.
- B. All materials in this Section are to be manufactured in the United States.

1.3 SUBMITTALS

- A. Comply with pertinent provisions of Section 01340.
- B. Product data: Within 30 calendar days after the Contractor has received the Owner's Notice to Proceed, submit:
 - 1. Materials list of items proposed to be provided under this Section.
 - 2. Manufacturer's specifications and other data needed to prove compliance with the specified requirements.
- C. Shop drawings shall show size of components, materials of construction, connection to other components and anchorage.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Finished and machined faces shall be true to line and level.
- B. Welding shall conform to applicable requirements of:

1. Steel products: American Welding Society Standard D1.0-63.
2. Aluminum alloy products: Recommended practices as published in "Welding Aluminum" by the American Welding Society.

C. Unless otherwise specified, materials shall conform to the following:

Structural Steel	ASTM A 36
Welded and Seamless Steel Pipe	ASTM A 53
Gray Iron Castings	ASTM A 48, Class 30
Galvanizing, General	ASTM A 123
Galvanizing, Hardware	ASTM A 153
Galvanizing, Assemblies	ASTM A 386
Aluminum (Extruded Shapes)	6063 T5 (Alum alloy)
Aluminum (Extruded Pipe)	6063 T6 (Alum alloy)
Aluminum Bars and Shapes (Structural)	6061 T6 (Alum alloy)
Bolts and Nuts	ASTM A 307
Stainless Steel Bolts, Fasteners	AISI Type 304
Stainless Steel Plate and Sheet, Wire	AISI Type 316
Welding Rods for Steel	AWS Spec for Arc Welding

D. Workmanship and finish shall be equal to the best practices of modern shops for the respective work.

1. Exposed surfaces shall have smooth finish and sharp, well defined lines and arises.
2. Sections shall be well formed to shape and size with sharp lines and angles.
3. Curved work shall be sprung evenly to curves.
4. Metal work shall be countersunk properly to receive hardware and provided with the proper bevels and clearance.
5. Cutting shall be done by shearing, sawing or flame cutting; if flame cut, the metal shall be ground back to smooth sound material.
6. Holes for bolts and screws shall be drilled.
7. Conceal fastenings where practicable.

2.2 STEEL AND IRON SHAPES

- A. Provide standard, well finished, structural shapes or commercial grade bar stock.
1. Structural steel shall conform to ASTM A 36.
 2. Rolled shapes shall conform to dimensions and weights of Regular Series Shapes of AISC.
- B. Pipe shall be Schedule 40, unless otherwise indicated.

2.3 ALUMINUM SHAPES

- A. Provide extruded shapes of 6063-T5 alloy unless another alloy is better suited for the intended purpose.

- B. Furnish structural shapes conforming to dimensions and weights of the Standard Structural Shapes of the Aluminum Association of 6061-T6.

2.4 ANCHOR BOLTS AND MISCELLANEOUS FASTENINGS

- A. General:
 - 1. Provide as indicated, or as necessary for securing work in place, and anchoring equipment in place.
 - 2. Sizes and spacing of anchor bolts not indicated shall be as required for the intended purpose.

- B. Provide anchor bolts, expansion anchors, epoxy adhesive anchors, nuts, washers and other fasteners of the materials indicated below unless otherwise indicated on the drawings.
 - 1. Fastening structural steel shapes and plates to each other - ASTM A 325 bolts.
 - 2. Anchoring structural steel to concrete - ASTM A 307 anchor bolts, galvanized.
 - 3. Fastening or anchoring stainless steel or aluminum to any material - Type 316 stainless steel.
 - 4. Anchoring process or mechanical equipment regardless of material to concrete - Type 316 stainless steel.
 - 5. Anchoring or fastening any materials that will be submerged in water or wastewater - Type 316 stainless steel.
 - 6. Any anchors or fasteners in contact with potable water - Type 316 stainless steel.
 - 7. Fastening or anchoring wood or timber in non-submerged application - hot dipped galvanized.
 - 8. Other fasteners and anchor bolts not otherwise specified - Type 316 stainless steel.
 - 9. In contact with chlorine solution - Type 2205 duplex stainless steel.

- C. Expansion anchors:
 - 1. Use stud type with one-piece wrap around expansion sleeve.
 - 2. Provide complete unit manufactured from 316 series stainless steel.
 - 3. Acceptable products: Phillips "Wedge-Anchors", Ramset "Trubolt Stud Anchors"; or Hilti "Kwik-Bolt".
 - 4. Do not use expansion anchors in masonry.

- D. Epoxy adhesive anchors:
 - 1. Provide injected epoxy adhesive anchors, consisting of screen tube and anchor rod.
 - 2. Anchor rod and nut to be Series 316 stainless steel.
 - 3. Acceptable products: Hilti "HIT" or equal.
 - 4. Use in masonry and where otherwise indicated.

2.5 INSERTS AND SLEEVES

- A. Provide as required and needed for support of piping, equipment and apparatus, or where passages through walls, floors, etc. are required.
- B. Size and material shall be as indicated, or as approved by the Engineer.

2.6 UNISTRUT CHANNELS

- A. Channels shall be accurately and carefully extruded to size from aluminum, except as noted otherwise.
- B. Channels embedded in concrete shall be Type 304 stainless steel.
- C. Provide a continuous slot with inturned clamping ridges on one side of channel.
- D. Fittings to be stainless steel or aluminum.
- E. Unless otherwise indicated on the drawings, channels to be 1-5/8" x 1-5/8" x .105" thick.
- F. Make all cuts square and free from burrs.
- G. Provide end caps on channels.
- H. Nuts, pipe hangers, clamps, etc. shall be units specifically intended and manufactured for use with "Unistrut" channels.
- I. All nuts, bolts and clamps shall be stainless steel.
- J. Provide flexible elastomer material, "Uni-cushion" or equal, between all pipe clamps or hangers and PVC, copper or stainless steel pipe.

2.7 ALUMINUM FLOOR GRATING

- A. General:
 - 1. Provide aluminum pressure locked Type B rectangular bar grating manufactured in compliance with the standards established by the National Association of Architectural Metal Manufacturers.
 - 2. Referenced manufacturer is IKG Industries, Ohio Gratings, Inc., or approved equal.
- B. Design:
 - 1. Provide grating with depth as indicated, but not less than that required to meet the criteria below.
 - 2. Design grating depth according to the following conditions:
 - a. Uniform Load - 100 lbs. per square foot.
 - b. Concentrated Load - 500 lbs. per linear foot applied at midspan of the grating.

- c. Deflection - Less than 1/4" at the above load.
- d. Minimum depth - 1-1/4".

C. Fabrication:

- 1. Band all panel edges and openings thru panels.
 - a. Provide banding bar 1/8" minimum thickness of the same depth as the bearing bars.
- 2. Provide aluminum bearing frames with anchor groove and specifically designed to fit the openings shown.
- 3. Provide adequate support at openings in grating and where grating span changes direction for grating system to meet specified load requirements.
 - a. Fabricate from aluminum structural shapes.
- 4. Miter, weld and ground smooth all frame corners.
- 5. Limit panel sizes to a maximum weight of 35 lbs. and no larger width than 30".
- 6. Coat all surfaces to be in contact with concrete with bituminous coating.
- 7. Provide each panel with four J-clip fasteners that do not extend above walking surface of the grating.
 - a. Do not provide fasteners that screw into the grating frame.
- 8. Grating material to be 6063-T6 aluminum alloy.
- 9. Provide mill finish.
- 10. Fabricate grating using 3/16" minimum thick rectangular bearing bars spaced at 1-3/16" on center.
- 11. Provide rectangular cross bars not less than 3/16" thick x 3/4" deep, spaced at no less than 4" on center and flush with the top of the bearing bars.
- 12. Slot bearing and cross bars with dovetail and rectangular slots, respectively, and pressure lock the bars together so that the dovetail slot in the bearing bars is filled solidly by the cross bars.
- 13. Unless otherwise indicated on the drawings, provide bearing and cross bars with non-skid serrated surface.

2.8 ALUMINUM GRATING FRAMES

- A. Provide aluminum bearing frames specifically designed to fit the openings shown and the grating provided.
- B. Provide grooved frame for J-clip fasteners.
- C. Provide frames with continuous anchor groove or welded anchors.
- D. Miter, weld and grind smooth all corners.

2.9 GALVANIZING

- A. Galvanizing of structural steel, where indicated on the drawings, shall be done in accordance with standard specification for zinc coating (hot-dip) ASTM designation A 123, A 153, A 143, A 384, A 386 and A 386 latest revision.
 - 1. Provide a minimum of 3 ounces of zinc per sq. ft. for members 1/4" thick and larger.
 - 2. Provide a minimum of 2 ounces of zinc per sq. ft. for members less than 1/4" thick.
 - 3. Fasteners - Comply with ASTM A 325 and ASTM A 153.
 - 4. Pickling is required prior to galvanizing.

2.10 SHOP PAINTING

- A. Clean and prime all ferrous metal surfaces with primer compatible with finish coats specified in Section 09900.

PART 3 - EXECUTION

3.1 GENERAL

- A. Install all items, plumb, square and level as intended.

3.2 MASONRY ANCHORS

- A. Drill hole in accordance with manufacturer's guidelines.
- B. Inject epoxy using manufacturer's approved injection equipment.
- C. Allow three hours cure time before putting a load on the anchors.
- D. Do not install if temperature is to be below 41°F during time required for cure.
- E. Apply "Never-Seize" to bolts and tighten nuts to manufacturer's recommendations using a torque wrench.
- F. Maximum protrusion of bolt from top of nut - 3/8".

3.3 ANCHOR BOLTS

- A. Drill holes to depth recommended by manufacturer.
- B. Apply "Never-Seize" to bolts.
- C. Tighten nuts to manufacturer's recommendations using a torque wrench.
- D. Maximum protrusion of bolt from top of nut - 3/8".

3.4 UNISTRUT CHANNELS

- A. Mount on wall or floor using stainless steel expansion or masonry anchors or embed in concrete where indicated.
- B. Install channels level and plumb.
- C. Install end caps.
- D. Attach securely to support structure with stainless steel wedge anchors.

3.5 ALUMINUM FLOOR GRATING

- A. Set frames level, blocking and bracing as necessary to prevent distortion during placing of concrete.
- B. Place grating panels in position and fasten at each corner.
- C. Clean surface of concrete, mud and other materials.

3.6 REPAIR OF HOT-DIPPED GALVANIZED SURFACES

- A. Comply with ASTM A 780.
- B. Repair using sprayed zinc coating, minimum dried film of 95% zinc by weight.
- C. Clean, dry and remove oil, grease, and corrosion products from surfaces.
- D. If the area to be reconditioned includes welds, first remove all flux residues and weld spatter by mechanical means, that is, chipping, etc.
- E. Wire brush clean the surface to be reconditioned in accordance with SSPC-SP3.
- F. Extend surface preparation into the surrounding undamaged galvanized coating.
- G. Apply the sprayed coating as soon as possible after surface preparation and before visible deterioration of the surface has occurred.
- H. Provide the surface of the sprayed coating with uniform texture, free of lumps, coarse areas, and loosely adherent particles.
- I. Provide dry mill thickness of 1 mil greater than specified for the hot-dipped galvanized material.
- J. Take thickness measurements with either a magnetic or electromagnetic gage to ensure that the applied coating is as specified.

3.7 MEASUREMENT AND PAYMENT

- A. No separate measurement or direct payment will be made for work under this Section, and the cost of same shall be included in the price bid for the item to which it pertains.

END OF SECTION

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SECTION 07920
SEALANTS AND CAULKING

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Work included: Throughout the Work, seal and caulk joints where shown on the Drawings and elsewhere as required to provide a positive barrier against passage of moisture and passage of air.
- B. Related work: Documents affecting work of this Section include, but are not necessarily limited to, General Conditions, Supplementary Conditions, and Sections in Division 1 of these Specifications.

1.2 QUALITY ASSURANCE

- A. Use adequate numbers of skilled workmen who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the work of this Section.

1.3 SUBMITTALS

- A. Comply with pertinent provisions of Section 01340.
- B. Product data: Within 30 days after the Contractor has received the Owner's Notice to Proceed, submit:
 - 1. Manufacturer's specifications and other data needed to prove compliance with the specified requirements.
 - 2. Color charts.

1.4 PRODUCT HANDLING

- A. Comply with pertinent provisions of Section 01640.
- B. Prevent subsection to temperatures exceeding 90°F.
- C. Do not retain at the job site material that has exceeded the shelf life recommended by its manufacturer.

PART 2 - PRODUCTS

2.1 SEALANTS

- A. Joint sealant:

1. Provide two-component polyurethane base elastomeric sealant complying with Federal Specification TT-S-00227E and ASTM C 920 and the following:

Material and Curing Conditions 73°F and 50% R.H.			
Service Range	-40° to 167° F		
Property	Non-sag	Self-Leveling	Test Method
Application life	3-4 hr	3-4 hr	TT-S-00227E
Tack-free Time	6-8 hr	6-8 hr	ASTM C-679
Final Cure	3 day	3 day	
Shore A Hardness	25±5	40±5	ASTM D-2240
Tensile Strength at Break	200 psi	200 psi	ASTM D-412
Tensile Elongation	650%	650%	ASTM D-412
100% Modulus	75 psi	100 psi	ASTM D0412
Tear Strength	125 lb/in	125 lb/in	ASTM D-624

Adhesion in Peel				TT-S-00227E
Substrate	Peel Strength	% Adhesion Loss	Peel Strength	% Adhesion Loss
Aluminum	30 lb	Zero	30 lb	Zero
Glass	30 lb	Zero	30 lb	Zero
Concrete	25 lb	Zero	30 lb	Zero

Weathering Resistance	Excellent
Ozone Resistance	Excellent
Chemical Resistance	Good resistance to water, diluted acids, diluted alkalines and residential sewage. Consult Technical Service for specific data.

2. Acceptable product: Sikaflex 2c by Sika Corporation or approved equal.

B. Building sealant:

1. Provide premium grade moisture cured one component polyurethane base elastomeric sealant complying with the following:

Material and Curing Conditions 73°F and 50% R.H.		
Service Range	-40° to 167° F	
Curing Rate	Tack-free Time	6 - 8 hours (TT-S-00340C)
	Tack-free to Touch	3 hours
	Final Cure	5 - 8 days
Recovery	>90%	
Shore A Hardness (ASTM D-2240)		
21 day	40±5	
Tensile Properties (ASTM D-412)		
21 day	Tensile Stress	140 psi
	Elongation at Break	700%
	Modulus of Elasticity 25%	40 psi
	50%	60 psi
	100%	80 psi
Lap-Shear Strength (ASTM D-1002), modified, glass substrate		
21 day	50°F	120 psi
	73°F	125 psi
	122°F	125 psi
Adhesion in Peel (TT-S-00230C)		
Substrate	Peel Strength	Adhesion Loss
Aluminum	25 lbs	10%
Glass	20 lb	5%
Concrete	20 lb	0%
Weathering Resistance	Excellent	
Ozone Resistance	Exceptional	
Chemical Resistance	Good resistance to water, diluted acids and diluted alkalines. Consult Technical Service for specific data.	

2. Acceptable product: Sikaflex 1a by Sika Corporation or approved equal.

- C. Do not install when the ambient or substrate temperature will be below 41° F or above 100° F for 24 hours.
- D. Color will be selected by the Engineer from standard colors normally available from the specified manufacturer.

2.2 PRIMERS

- A. Provide in accordance with recommendations of the manufacturer of the sealant used.

2.3 BACKUP MATERIALS

- A. Use closed cell neoprene cord, closed cell polyethylene foam rod, or closed cell sponge of vinyl or rubber.

2.4 BOND PREVENTATIVE MATERIALS

- A. Use only one of the following as best suited for the application, and as recommended by the manufacturer of the sealant use:
 - 1. Polyethylene tape, pressure sensitive adhesive, with the adhesive required only to hold tape to the construction materials as indicated.
 - 2. Aluminum foil complying with MIL-A-148E.
 - 3. Wax paper complying with Federal Specification UU-P-270.

2.5 MASKING TAPE

- A. For masking around joints, provide masking tape complying with Federal Specification UU-T-106c.

PART 3 - EXECUTION

3.1 GENERAL

- A. Caulk all joints about the perimeter of window and door frames, louvers, dampers, exhaust fans and other exterior openings.
- B. Caulk all concrete and masonry expansion joints.
- C. Caulk where indicated on the drawings.

3.2 PREPARATION

- A. Clean all surfaces to receive caulking of all loose particles, dirt, dust, oil, grease and other foreign matter.

3.3 INSTALLATION OF BACKUP MATERIAL

- A. Install backup material so that joint depth will not exceed one half joint width, except minimum depth shall be 1/4".
- B. Compress material 25% to 50% to achieve a positive and secure lift.
- C. When using backup of tube or rod stock, avoid lengthwise stretching of the material. Do not twist or braid hose or rod backup stock.

3.4 PRIMING

- A. Use only the primer recommended by the manufacturer of the sealant, applying in strict accordance with the manufacturer's recommendations.

3.5 BOND BREAKER INSTALLATION

- A. Provide an approved bond breaker where recommended by the manufacturer of the sealant, and where directed by the Engineer, adhering strictly to the installation recommendations.

3.6 INSTALLATION OF SEALANTS

- A. Equipment:
 - 1. Apply non-sag sealants under pressure with power actuated or handgun, or by other appropriate means.
 - 2. Use guns with nozzle of proper size, and providing sufficient pressure to completely fill the joints as designed.
- B. Thoroughly and completely mask joints where the appearance of sealant on adjacent surfaces would be objectionable.
- C. Install the sealant in strict accordance with the manufacturer's recommendations as approved by the Engineer, thoroughly filling joints to the recommended depth.
- D. In horizontal joints, pour self-leveling sealant into joint slot moving in one direction and allow sealant to flow and level out.
- E. In vertical or sloped joints, place non-sag sealant using bulk gun or follower plate loading system and tool joint to a slight concave profile.
- F. Cleaning up:
 - 1. Remove masking tape immediately after joints have been tooled.
 - 2. Clean adjacent surfaces free from sealant as the installation progresses, using solvent or cleaning agent recommended by the manufacturer of the sealant used.

3.7 MEASUREMENT AND PAYMENT

- A. No separate measurement or direct payment will be made for work under this section, and cost of same shall be included in the price bid for the structure in which the work is incorporated.

END OF SECTION

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SECTION 08100

METAL DOORS AND FRAMES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Work included: Provide metal doors, and metal door frames which are not specifically described in other Sections of these Specifications, where shown on the Drawings, as specified herein, and as needed for a complete and proper installation.
- B. Related work:
 - 1. Documents affecting work of this Section include, but are not necessarily limited to, General Conditions, Supplementary Conditions, and Sections in Division 1 of these Specifications.
 - 2. Section 08710 - Finish Hardware.

1.2 QUALITY ASSURANCE

- A. Use adequate numbers of skilled workmen who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the work of this Section.
- B. Unless specifically otherwise approved by the Engineer, provide all products of this Section from a single manufacturer.

1.3 SUBMITTALS

- A. Comply with pertinent provisions of Section 01340.
- B. Product data: Within 15 calendar days after the Contractor has received the Owner's Notice to Proceed, submit:
 - 1. Materials list of items proposed to be provided under this Section.
 - 2. Manufacturer's specifications and other data needed to prove compliance with the specified requirements.
 - 3. Shop Drawings showing details of each frame type, elevations of door designs, details of openings, and details of construction, installation and anchorage.
 - 4. Show door swings as LH, RH, LHR or RHR.
 - 5. Manufacturer's recommended installation procedures which, when approved by the Engineer, will become the basis for accepting or rejecting actual installation procedures used on the Work.

1.4 PRODUCT HANDLING

- A. Comply with pertinent provisions of Section 01640.

PART 2 - PRODUCTS

2.1 METAL DOORS

A. Type and design:

1. Provide full flush design, in dimensions and types shown on the Drawings, in 14 gauge galvanized steel face sheets for all doors.
2. All steel components to be hot dipped galvanized having an A60 zinc coating in the 0.60 oz. coating class, conforming to ASTM A525.
3. Provide all welded construction with no seams or joints on door faces.
4. Provide full length continuous welded vertical edges, ground smooth.
5. Provide sound absorbing polyethylene material within the door.
6. Close top and bottom edges of exterior doors with a 12 gauge continuous flush galvanized steel channel to provide weather seal as part of door construction.
7. Reinforce doors for door hardware as follows:
 - a. Lock - One piece full height 10 gauge galvanized steel channel continuously welded to face sheets.
 - b. Hinges - One piece full height 12 gauge galvanized steel channel continuously welded to face sheets.
 - c. Closures - 5" x 16", 12 gauge galvanized steel channel.
 - d. Overhead holders - 5" x 24", 12 gauge galvanized steel channel.
 - e. Panic bars - 5" x 18", 14 gauge galvanized steel channel.
8. Louvers where indicated are to be 14 gauge galvanized steel blades welded or tenoned to frame.
 - a. Provide exterior doors with stainless steel screen.
9. For double leaf door, provide continuously welded galvanized steel astragal on active leaf.

B. Finish:

1. Pre-clean and shop prime each door for finish painting which will be performed at the job site under Section 09900 of these Specifications.

2.2 METAL FRAMES

A. Type and design:

1. Provide frames of the types and dimensions shown on the Drawings, in 12 gauge galvanized steel in accordance with ASTM A525 for all doors.
2. All steel components to be hot dipped galvanized having an A60 zinc coating in the 0.60 oz. coating class, conforming to ASTM A525.
3. Provide hardware reinforcement as follows:
 - a. Hinges - 7 gauge galvanized steel x 1-5/8" x 10"
 - b. Lock strike - 14 gauge galvanized steel x template requirements
 - c. Closure - 12 gauge galvanized steel x contour of head x 16"
4. Miter and weld full length of corner joints, grind smooth.
5. Provide 1/2" wide door stops.
6. Punch three silencer holes in latch jamb of single frames and one silencer hole per leaf in head jamb of double frames.

7. Provide dust boxes of not less than 11 gauge galvanized steel over strikes and protection for tapped holes not less than 26 gauge.
 8. Provide adjustable, clip-angle type jamb anchors, not less than 12 gauge galvanized steel, securely attached to the bottom of each jamb.
- B. Finish:
1. Pre-clean and shop prime each frame.
 2. Finish painting to be performed at the job site under Section 09900 of these Specifications.

2.3 FINISH HARDWARE

- A. Secure templates from the finish hardware supplier and accurately install, or make provision for, all finish hardware at the factory.

PART 3 - EXECUTION

3.1 SURFACE CONDITIONS

- A. Examine the areas and conditions under which work of this Section will be performed. Correct conditions detrimental to timely and proper completion of the Work. Do not proceed until unsatisfactory conditions are corrected.

3.2 INSTALLATION

- A. Placing frames:
1. Where practicable, place frames prior to construction of enclosing walls and ceilings.
 2. Set frames accurately into position, plumbed, aligned, and braced securely until permanent anchors are set.
 3. After wall construction is completed, remove temporary braces and spreaders, leaving surfaces smooth and undamaged.
 4. Anchor bottom of frames to floors with expansion bolts and power fasteners.
 5. At in place construction, set frames and build wall anchors into adjacent walls or secure to adjacent construction with machine screws and suitable anchorage devices. Provide "Z" fillers at each screw hole.
 6. When installed in prepared openings in concrete or masonry construction, provide sealant between frame and concrete in accordance with provisions of Section 07920 of these Specifications.
- B. Hanging doors:
1. Provide metal doors in locations as required.
 2. Install all finish hardware and adjust as necessary for proper operation.

3.3 ADJUST AND CLEAN

- A. Final adjustments:
 - 1. Check and readjust operating finish hardware items in hollow metal work just prior to final inspection.
 - 2. Leave work in complete and proper operating condition.
 - 3. Remove defective work and replace with work complying with the specified requirements.

- B. Immediately after erection, sand smooth all rusted and damaged areas of prime coat, and apply touch-up of compatible air drying primer.

3.4 MEASUREMENT AND PAYMENT

- A. No separate measurement or direct payment will be made for this work and all costs for same shall be included in the price bid for the item to which it pertains.

END OF SECTION

SECTION 08710

FINISH HARDWARE

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Work included:
 - 1. Furnish finish hardware required to complete the Work as shown on the Drawings and as specified herein.
 - 2. Furnish trim attachments and fastenings, specified or otherwise required, for proper and complete installation.
 - 3. Deliver to the job site those items of finish hardware scheduled to be installed at the job site.
- B. Related work:
 - 1. Documents affecting work of this Section include, but are not necessarily limited to, General Conditions, Supplementary Conditions and Sections in Division 1 of these Specifications.
 - 2. Installation of finish hardware is described in other Sections of these Specifications.
 - 3. Section 08100 - Metal Doors and Frames.
- C. Definitions:
 - 1. "Hardware sets" described in the Hardware Schedule in Part 3 of this Section are as shown on the Drawings.

1.2 QUALITY ASSURANCE

- A. Referenced hardware listed herein is from the following catalogs:
 - 1. Locksets and cylinders - Corbin Russwin.
 - 2. Butts - Stanley Works.
 - 3. Thresholds and weatherstripping - Pemko.
 - 4. Closers - Norton.
 - 5. Overhead holders - Glynn Johnson.
 - 6. Surface bolts, flush bolts, door and wall stops, silencers, and kick, push and pull plates - H. B. Ives.
- B. Comparable hardware of other manufacturers will be acceptable, provided a complete list is submitted for approval by the Engineer.

1.3 SUBMITTALS

- A. Comply with pertinent provisions of Section 01340.
- B. Product data: Within __ calendar days after the Contractor has received the Owner's Notice to Proceed, submit:
 - 1. Materials list of items proposed to be provided under this Section.
 - a. Approval of this list by the Engineer will not relieve the Contractor of the responsibility to provide all finish hardware items required for the Work, even though such required items may not have been shown on the approved list.
- C. Templates: In a timely manner to assure orderly progress of the Work, deliver templates or physical samples of the approved finish hardware items to pertinent manufacturer's of interfacing items such as doors and frames.

1.4 PRODUCT HANDLING

- A. Comply with pertinent provisions of Section 01640.
- B. Individually package each unit of finish hardware, complete with proper fastenings and appurtenances, clearly marked on the outside to indicate contents and specific locations in the Work.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Fasteners:
 - 1. Furnish necessary screws, bolts, and other fasteners of suitable size and type to anchor the hardware in position for long life under hard use in accordance with the hardware manufacturer.
 - a. Anchor bolts to be Type 316 stainless steel.
 - 2. Provide fasteners which harmonize with the hardware as to finish and material.
 - a. Fasteners to be aluminum or stainless steel.

2.2 MASTER KEYING

- A. Provide all locks equipped with an interchangeable core, removable by the Owner's master (control) key.
- B. Master key all permanent (security) cores to the Owner's grand master keyed system as directed by the Owner.
- C. Cores to have a figure eight face and six-pin tumbler locking core.
- D. All locks shipped to the Contractor shall have temporary construction cores with two control keys and three master keys.
- E. Upon completion of all items on final "punch list" and as final act in turning the project over to the Owner:
 - 1. In the presence of the Owner's representative, replace all temporary cores with the master keyed permanent cores.
 - 2. Provide Owner with no less than:
 - a. Four master keys.
 - b. Six keys for each different set of locks.

2.3 FINISH

- A. Unless otherwise indicated, all hardware shall have **US32D** finish.

2.4 OTHER MATERIALS

- A. Provide other materials, not specifically described but required for a complete and proper installation, as selected by the Contractor subject to the approval of the Engineer.
- B. Provide adequate mounting hardware to install closure on interior of buildings.

PART 3 - EXECUTION

3.1 LOCATION

- A. Hardware on hinged doors shall be located as follows, unless otherwise indicated:
1. Locks - Knobs shall be installed at the same height, approximately 37" above the finish floor, throughout the buildings.
 2. Hinges - Locate as follows:
 - a. Top Hinge: Not over 9-3/4" from the inside of frame rabbet at head to center of hinge.
 - b. Bottom Hinge: Not over 10-3/8" from finished floor to center of hinge.
 - c. Center Hinge: Midway between top and bottom hinges.

3.2 FINISH HARDWARE SCHEDULE

- A. Furnish the following hardware groups in the amounts indicated on the Drawings.

1. Hardware Set #3 - (Building entrance doors, opening to outside)

Each door to have:

3 each Butts - FBB199 - 4-1/2 x 4-1/2 - US32D - NRP
1 each Closer - 7500SS - AL - SN (less arm)
1 each Closer Arm (w/stop/holder) 6870T-8 SRI x 689
1 each Lockset - ML 2024 - ASM 630 CT6
1 each Threshold - 181AS x Length Required
1 set Weatherstrip - 315 CR x Length Required
1 each Floorstop w/Holder - 446 B26D
3 each Silencers - 20

2. Hardware Set #10 - (Double leaf doors, building entrance, opening to outside)

Each pair of doors to have:

6 each Butts - FBB199 - 4-1/2 x 4-1/2 - US32D - NRP
2 each Flush Bolts - 458-B26D
1 each Closer - 7500SS - AL - SN (less arm) (Active Leaf)
1 each Closer Arm (w/stop/holder) 6870T-8 SRI x 689
1 each Lockset - ML 2024 - ASM - 630 CT6
1 each O.H. Holder - Series 79H-S3 (Inactive Leaf)
1 each Threshold - 181AS x Length Required
1 set Weatherstrip - 315CR x Length Required
1 each Astragal - 355CP x Length required (Active Leaf)
1 each Dummy Trim - ML2070-ASM 630

3.3 MEASUREMENT AND PAYMENT

- A. No separate measurement or direct payment will be made for work under this Section, and the cost of same shall be included in the price bid for the item to which it pertains.

END OF SECTION

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SECTION 09900

PAINTING

PART I - GENERAL

1.1 WORK INCLUDED

- A. The contractor shall furnish all materials, labor, equipment, and incidentals required to provide a protective coating system for the surfaces listed herein and not otherwise excluded.
- B. The work includes painting and finishing of interior and exterior exposed items and surfaces such as structural steel, miscellaneous metals, ceilings, walls, floors, doors, frames, transoms, roof fans, construction signs, guardrails, posts, fittings, valves, equipment, and all other work obviously required to be painted unless otherwise specified herein or on the drawings. The omission of minor items in the schedule of work shall not relieve the contractor of his obligation to include such items where they come within the general intent of the specification as stated herein.
- C. The following items will not be painted:
 - 1. Any code-requiring labels, such as Underwriters' Laboratories and Factory Mutual, or any equipment identification, performance rating, name or nomenclature plates.
 - 2. Any moving parts of operating units, mechanical and electrical parts, such as valve and damper operators, linkages, sinkages, sensing devices, motor and fan shafts, unless otherwise indicated.
 - 3. Aluminum handrails, walkways, windows, louvers and grating unless otherwise specified herein.
 - 4. Signs and nameplates.
 - 5. Finish hardware.
 - 6. Stainless steel angles, tubes, pipe, etc.
 - 7. Products with polished chrome, aluminum, nickel, or stainless steel finish.
 - 8. Plastic switch plates and receptacle plates.
 - 9. Flexible couplings, lubricated bearing surfaces, insulation and metal and plastic pipe interior.
 - 10. Sprinkler heads.

1.2 REFERENCES

- A. SSPC - Steel Structures Painting Council.
- B. Metal Ladder Manufacturer's Association - Specification for Ladders and Scaffolds.
- C. UL Requirement for Ladders and Scaffolds.

1.3 QUALITY ASSURANCE

- A. Workmanship shall be performed by skilled workmen thoroughly trained in necessary crafts and completely familiar with specific requirements and methods specified herein.
- B. All materials shall be produced by a single manufacturer. Total paint system shall be from one manufacturer and no cross coating allowed between primers and finish coats.

1.4 SUBMITTALS

- A. Submit manufacturer's printed literature and other data as required to certify compliance with requirements and systems specified herein.
- B. Colors to be selected by Engineer, and indicated on schedule.
- C. Samples:
 - 1. Samples of each finish and color shall be submitted to the Architect/Engineer for approval before any work is started.
 - 2. Such samples when approved in writing shall constitute a standard, as to color and finish only, for acceptance or rejection of the finish work.
 - 3. Rejected samples shall be resubmitted until approved.
- D. VOC Requirements: Submit manufacturer's certification that paints and coatings comply with Federal, State, and Local, whichever is more stringent, requirements for VOC (Volatile Organic Compound).

1.5 DELIVERY, HANDLING AND STORAGE

- A. Deliver all material to site in original, new, unopened containers, labeled and bearing manufacturer's name and stock number, product and brand name, contents by volume for major constituents, instructions for mixing and reducing, and application instruction.
- B. Provide adequate storage facilities designed exclusively for the purpose of paint storage and mixing. Facility area shall be located away from open flames, be well ventilated, and be capable of maintaining ambient storage temperature of no less than 45 degrees F.
- C. Paint, coatings, reducing agents, and other solvents must be stored in original containers until opened; if not resealable, then must be transferred to UL approved safety containers. Provide proper ventilation, personal protection and fire protection for storage and use of same.
- D. Comply with requirements set forth by Occupational Safety and Health Act, OSHA, for storage and use of painting materials and equipment.

1.6 EXTRA STOCK

- A. Upon completion of work, provide owner with at least one gallon of each type and color of product used.
- B. Containers shall be tightly sealed and clearly labeled for identification.

PART 2 - PRODUCTS

2.1 ACCEPTABLE SYSTEMS AND MANUFACTURERS

- A. Materials specified are those that have been evaluated for the specific service. Products of the Tnemec Co. are listed to establish a standard of quality. Equivalent "or equal" materials of other manufacturers may be substituted by the contractor on written approval of the Owner.

Local Field Tnemec Technical Support: Tnemec Company, 101 Rice Bent Way Suite 5 Columbia, SC 29229. Phone: (803) 736-1553 Email: TSE@tnemec.com

- B. Requests for substitution shall include manufacturer's literature for each product giving the name, product number, generic type, descriptive information, solids by volume, recommended dry film thickness, certified test reports showing results to equal the performance criteria of the products specified herein, cost per gallon/unit and cost savings. No request for substitution shall be considered that will decrease film thickness or offer a change in the generic type of coatings specified. In addition, a list of five similar projects shall be submitted in which each product has been used and rendered satisfactory service for at least 5 years.

Requests for product substitution shall be made at least thirty (30) days prior to bid date.

Any material savings shall be passed to the owner in the form of a contract dollar reduction.

Manufacturer's color charts shall be submitted to the Owner at least 30 days prior to paint application. General contractor and painting contractor shall coordinate work so as to allow sufficient time (five to ten days) for paint to be delivered to the jobsite.

2.2 MATERIALS

- A. Tnemec Company, Inc., North Kansas City, Missouri.
B. Or Equal

PART 3 - EXECUTION

3.1 INSPECTION

- A. Thoroughly examine surface scheduled to be painted prior to commencing work. Report in writing to the Engineer any condition that may affect proper application and overall performance of coating system. Do not proceed with work until such conditions have been corrected. Commencing with work indicates acceptance of existing conditions and for responsibility for performance of applied coating.

3.2 PROTECTION

- A. Extreme diligence shall be taken to ensure that vehicles, equipment, hardware, fixtures, materials, etc., are protected against paint spillage, overspray, etc. Such damages shall be corrected at no expense to Owner.
- B. Surfaces not to be coated shall be masked, removed, or otherwise covered to protect against cleaning and coating application procedures and weather. Drop cloths shall be used to protect floor, walls, machinery, equipment, and previously coated surfaces.
- C. Exercise care in erecting, bracing, handling, and dismantling staging and scaffolding, to avoid scratching or damaging walls, floors, equipment, etc.

3.3 SURFACE PREPARATION

- A. Perform preparation and cleaning procedures in strict accordance with manufacturer's instructions for each substrate condition.
- B. Ferrous metals (structural steel and miscellaneous metals) requiring shop or field priming shall be prepared as listed in PART 4 "Coating System Schedule" specified herein and listed for each individual coating system. All metal surfaces shall be cleaned prior to sandblasting to remove oil and grease present by following methods and procedures outlined in SSPC-SP1 Solvent Cleaning.
- C. Surface preparation for field touch-up of ferrous metals shop-primed shall be as follows:
 - 1. Immersion - Remove all oil, grease, dirt, dust and foreign matter from the surface. Weld slag, weld spatter, rough edges and sharp corners of weld seams shall be ground smooth. All rusted, abraded and unpainted areas shall be blast cleaned to a Near-White Finish as outlined in Steel Structures Painting Council's Specification SP-10.
 - 2. Non-Immersion - Remove all oil, grease, dirt, dust and foreign matter from the surface. Follow cleaning with Steel Structures Painting Council's Specification SP-3 Power Tool cleaning.
- D. Galvanized metals requiring paint (only as directed by Engineer) shall be cleaned by removing all oil, grease, dirt, dust and foreign matter by solvent cleaning in accordance with SSPC-SP1 prior to applying any finish.
- E. Concrete and concrete masonry surfaces shall be cleaned and free of oils, laitance, dust, dirt, loose mortar, and excess moisture. Structural cracks and defects shall be repaired. All surfaces must be completely dry prior to applying any coatings/paint.
- F. Gypsum board (or drywall) surfaces shall be dry, flat, and free of dust, dirt, grease, oil, powdery residue, wax, soap and other contaminants.

3.4 TOUCH-UP OF SHOP APPLIED COATINGS

- A. All shop applied coatings with manufacturer's standard paint and in non-immersion service, shall be touched-up with compatible barrier coating, Tnemec Series 135 Chembuild, able to receive specified topcoat(s). Notify the Engineer in writing of anticipated problems due to incompatible coating systems.
- B. All shop applied coatings with specified primer as listed in PART 4 "Coating System Schedule" shall be touched up with same primer before any topcoat(s) are applied.

3.5 APPLICATION

- A. No paint shall be applied when surrounding air temperature, as measured in the shade, is below 45 degrees F. No paint shall be applied when the temperature of the surface to be painted is below 40 degrees F. Paint shall not be applied to wet or damp surfaces, and shall not be applied in rain, snow, fog or mist, or when the relative humidity exceeds 85%. Paint shall not be applied when the substrate temperature is within 5 degrees of the dewpoint. Paint manufacturer's temperature guidelines must be followed.
- B. No paint shall be applied when it is expected that the relative humidity will exceed 85% or that the air temperature will drop below 45 degrees F within 4 hours after the application of the paint.
- C. Maintain proper ventilation in area of work to alleviate volatile solvents evaporating from coating materials.
- D. All ingredients in any container of the coating materials shall be thoroughly mixed and shall be agitated often enough during application to keep the pigment suspended.
- E. Should thinning be required use only the amounts specified by the coating manufacturer.
- F. Application of coating shall be by brush, roller, mitt, or spray and in accordance with manufacturer's recommendations. All material shall be evenly applied to form a smooth, continuous, unbroken coating. Drips, runs, sags, or pinholes shall not be acceptable.
- G. Provide proper application equipment, including ladders, scaffolding, masking materials, and tools to perform work. Ladders and scaffolding shall meet or exceed UL requirements and Metal Ladder Manufacturer's Association.
- H. Meet all requirements set forth by Occupational Safety and Health Act, OSHA, for confined space.

3.6 SYSTEM INSPECTION AND TESTING

- A. After application of each coating in the specified system and its surface has cured, measure its thickness with a properly calibrated Nordson Microtest Dry Film Thickness Gauge, or equivalent. Follow standard method for measurement of dry paint thickness with magnetic gauges as outlined in Steel Structures Painting Council's SSPC-PA2
- B. Make as many determinations as needed to ensure the specified thickness values in each typical area. To all surfaces having less dry film thickness than specified, apply additional coat(s) at no extra cost to Owner to bring thickness up to specifications.
- C. Structural metals in immersion service that receive a protective coating system shall be checked with a non-destructive holiday detector that shall not exceed 67 1/2 volts. All pinholes or defects shall be repaired in accordance with manufacturer's printed recommendations and then retested.
- D. Masonry, drywall, or other non-metallic surfaces shall be continuously checked with wet-film thickness gauges during application to ensure proper dry film thickness will be attained. Also, square feet coverage needs to be monitored to verify proper coverage rates.
- E. Painting contractor shall permit Engineer and/or paint & coating manufacturer (as requested by owner) to inspect his work for conformance to this specification. Owner reserves the right to reject all work that does not comply with this specification.

3.7 CLEAN-UP

- A. Upon completion, painting contractor shall clean up and remove from site all surplus materials, tools, appliances, empty cans, cartons, and rubbish resulting from painting work. Site shall be left in neat, orderly condition.
- B. Remove all protective drop cloths and masking from surfaces not being painted. Provide touch-up around same areas as directed by Engineer.
- C. Remove all misplaced paint splatters or drippings resulting from this work.

PART 4 - COATING SYSTEM SCHEDULE

4.1 STEEL - STRUCTURAL, TANKS, PIPES AND EQUIPMENT

A. Exterior/Interior Exposure

Dry Film-Mils

Surface Preparation: SSPC-SP6 Commercial Blast Cleaning

<u>Shop Coat:</u>	Tnemec Series 1 Omnithane	2.5 - 3.5
<u>2nd Coat:</u>	Tnemec Series 66 Hi-Build Epoxoline	4.0 - 5.0
<u>3rd Coat:</u>	Tnemec Series 73 Endura-Shield	<u>3.0 - 4.0</u>
		9.5 - 12.5

B. Interior Exposure

Dry Film-Mils

Surface Preparation: SSPC-SP6 Commercial Blast Cleaning

<u>Shop Coat:</u>	Tnemec Series 1 Omnithane	2.5 - 3.5
<u>2nd Coat:</u>	Tnemec Series 66 Hi-Build Epoxoline	4.0 - 5.0
<u>3rd Coat:</u>	Tnemec Series 66 Hi-Build Epoxoline	<u>4.0 - 5.0</u>
		10.5 - 13.5

4.2 GALVANIZED STEEL - PIPE AND MISCELLANEOUS FABRICATIONS

A. Exterior/Interior Exposure (Non-Immersion)

Dry Film-Mils

Surface Preparation: SSPC-SP7 Brush-off blast. Exterior surfaces to be cleaned as required by manufacturer.

<u>1st Coat:</u>	Tnemec Series 66 Hi-Build Epoxoline	4.0 - 5.0
<u>2nd Coat:</u>	Series 73 Endura-Shield	<u>3.0 - 4.0</u>
		7.0 - 9.0

B. Interior Exposure (Non-immersion)

Dry Film-Mils

Surface Preparation: SSPC-SP1 Solvent Cleaning

<u>1st Coat:</u>	Tnemec Series 66 Hi-Build Epoxoline	4.0 - 5.0
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4.3 CONCRETE FLOORS

A. Urethane Floor Coating

Surface Preparation: SSPC-SP13/NACE; ICRI CSP3.

<u>1st Coat:</u>	Tnemec Series 201 Epoxoprime	190 Sq. Ft./Gal. (8.0 dry mils)
<u>2nd Coat:</u>	Tnemec Series 280 Tneme-Glaze	200 Sq. Ft./Gal. (8.0 dry mils)
<u>3rd Coat:</u>	Tnemec Series 291 CRU	537 Sq. Ft./Gal. (2.0 dry mils)

4.4 POROUS MASONRY

A. Exterior Exposure

Surface Preparation: Surface shall be clean and dry.

<u>1st Coat:</u>	Tnemec Series 130 Envirofill Masonry Filler (Fill all voids)	60-80 Sq. Ft./Gal. (10.0 dry mils)
<u>2nd Coat:</u>	Tnemec Series 66 Hi-Build Epoxoline	(5.0 dry mils)
<u>3rd Coat:</u>	Tnemec Series 66- Hi-Build Epoxoline	(5.0 dry mils)

B. Interior Exposure (Non-immersion)

Surface Preparation: Surface shall be clean and dry.

<u>1st Coat:</u>	Tnemec Series 130 Envirofill Masonry Filler (Fill all voids)	60-80 Sq. Ft./Gal. (10.0 dry mils)
<u>2nd Coat:</u>	Tnemec Series 66 Hi-Build Epoxoline	(5.0 dry mils)
<u>3rd Coat:</u>	Tnemec Series 66- Hi-Build Epoxoline	(5.0 dry mils)

4.5 CONCRETE

A. Exterior - Above Grade

Dry Film-Mils

Surface Preparation: Surface shall be clean and dry.

<u>One Coat:</u>	Series 181 W.B. Tneme-Crete	90 Sq. Ft./Gal. (10.0 dry mils)
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B. Interior Exposure (Non-immersion)

Surface Preparation: Surface shall be clean and dry.

<u>1st Coat:</u>	Series 66 Hi-Build Epoxoline	180 Sq. Ft./Gal. (5.0 dry mils)
<u>2nd Coat:</u>	Series 66 Hi-Build Epoxoline	180 Sq. Ft./Gal. (5.0 dry mils)

END OF SECTION

SECTION 10520

FIRE EXTINGUISHERS AND CABINETS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Work included: Provide fire extinguishers and cabinets where shown on the Drawings, as specified herein, and as needed for a complete and proper installation.
- B. Related work:
 - 1. Documents affecting work of this Section include, but are not necessarily limited to, General Conditions, Supplementary Conditions, and Sections in Division 1 of these Specifications.

1.2 QUALITY ASSURANCE

- A. Use adequate numbers of skilled workmen who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the work of this Section.

1.3 SUBMITTALS

- A. Comply with pertinent provisions of Section 01340.
- B. Product data: Within 30 calendar days after the Contractor has received the Owner's Notice to Proceed, submit:
 - 1. Materials list of items proposed to be provided under this Section.
 - 2. Manufacturer's specifications and other data needed to prove compliance with the specified requirements.
 - 3. Dimensioned drawings as needed to depict the space required for these items, and their interface with the work of other trades.
 - 4. Manufacturer's recommended installation procedures which, when approved by the Engineer will become the basis for accepting or rejecting actual installation procedures used on the Work.

1.4 PRODUCT HANDLING

- A. Comply with pertinent provisions of Section 01640.

PART 2 - PRODUCTS

2.1 CABINETS

- A. Where shown on the Drawings, provide J.L. Industries, Norris Industries or W.D. Allen Manufacturing Co. factory prefinished steel cabinets, or equal products of other manufacturers.

1. Tubs shall be 18 gauge epoxy coated steel.
2. Semi-recessed units, 12"W x 27"H x 8"D, projecting 2", clear anodized aluminum trim and full glass door, double strength glazing and Futra "FIRE" handle.
3. Surface mounted cabinets, same as above except 14"W x 29"H by 8"D.

2.2 FIRE EXTINGUISHERS

- A. At each fire extinguisher cabinet, provide one multi purpose chemical fire extinguishers with UL rating of 20A-80BC, J.L. Industries Model Cosmic 20E, or equal.
- B. Service, charge, and tag each fire extinguisher not more than five calendar days prior to the Date of Substantial Completion of the work as that date is established by the Engineer.

PART 3 - EXECUTION

3.1 SURFACE CONDITIONS

- A. Examine the areas and conditions under which work of this section will be performed. Correct conditions detrimental to timely and proper completion of the Work. Do not proceed until unsatisfactory conditions are corrected.

3.2 INSTALLATION

- A. Coordinate as required with other trades to assure proper and adequate provision in the work of those trades for interface with the work of this Section.
- B. Install the work of this Section in strict accordance with the original design, the approved Shop Drawings, pertinent requirements of governmental agencies having jurisdiction, and the manufacturer's recommended installation procedures as approved by the Engineer, anchoring all components firmly into position for long life under hard use.

3.3 MEASUREMENT AND PAYMENT

- A. No separate measurement or direct payment will be made for the work under this Section and all costs for same shall be included in the price bid for the item of which it is a part.

END OF SECTION

SECTION 13310
SUPERVISORY CONTROL AND DATA ACQUISITION SYSTEM

PART 1 - GENERAL

1.1 SCADA SYSTEM DESCRIPTION

A. Work included: Provide upgrades to the existing supervisory control and data acquisition system (SCADA) with appurtenant equipment and accessories as indicated, specified, and as necessary for a complete and proper operating system.

1. Work includes, but is not necessarily limited to, the following:

- a. New PLC based RTU-1 in the electrical building to control/monitor the 2 City pumps and site I/O. RTU-1 will replace the existing RTU-1 and expand the I/O. RTU-1 communicates with the water treatment plant over City-owned fiber.
- b. New PLC based RTU-2 in the electrical building to control/monitor the 2 Steel City pumps. RTU-2 communicates with the Steel City Alarm Panel over a cellular network.
- c. New Liberty Steel Alarm Panel located at Liberty Steel Facility.
- c. All engineering, hardware and software installation, and supervision necessary.
- d. Testing and operational demonstrations as specified.
- e. Training programs as specified.
- f. Preparation of operation and maintenance manuals.
- g. Preparation of Record Prints.

B. Major components of the SCADA system include but are not limited to:

Designation	Description – Location	Status, Note
RTU-1	Raw Water Pump Station (City Pumps)	New
RTU-2	Raw Water Pump Station (Liberty Steel Pumps)	New
L.S. Alarm Panel	Cellular Alarm Panel (Liberty Steel Facility)	

D. Related work:

- 1. Documents affecting work of this Section include, but are not necessarily limited to, General Specifications, Special Provisions, and Sections in Division 1 of these Specifications.
- 2. Section 16400 - Electrical.
- 3. Section 16480 – Variable Frequency Drives

1.2 QUALITY ASSURANCE

A. These specifications cover the intended functionality of the equipment, but do not necessarily cover all details necessary for a complete, operable and functional system. The Instrumentation

and Control System Integrator shall supply all devices and appurtenances necessary to provide a complete, operable and satisfactory system as indicated or specified.

B. Instrumentation and Control System Integrators:

1. It is the intent of these specifications and drawings that the Contractor shall engage a pre-approved and qualified Instrumentation and Control System Integrator to provide the system as specified and indicated.
2. Responsibilities of the Instrumentation and Control System Integrator to include:
 - a. Furnish a complete, integrated and functionally operating system, warranted to perform the intended functions as herein specified.
 - b. Provide or supply all hardware and software specified herein or required and provide all required and specified collateral services in connection with the system such as testing, calibration, start-up, operation and maintenance manuals, record prints, and operator training without additional cost to the Owner.
3. The Instrumentation and Control System Integrator shall have been fully engaged in the business of installing SCADA systems for the municipal water and wastewater market for a period of at least ten (10) years.
4. Referenced Integrator is CITI, Inc of Charlotte, NC and is named to maintain existing service agreements and compatibility with the existing system.
5. The CITI Scope Proposal is included at the end of this section.

C. Contractor:

1. Shall be fully and solely responsible for the work of the systems supplier and solely responsible to the Owner for having supplied to the Owner the complete supervisory control and data acquisition system.
2. To provide personal superintendence and direction to the work, maintaining and supplying complete supervision over and coordination between all subcontractors employed by him.
3. To be responsible for defining the limits of his subcontractor's work.
4. Physical mounting/setting of all control panels shall be made by the Contractor and/or electrical subcontractor.
5. Terminations of field wiring shall be made by the Contractor and/or the electrical subcontractor.

D. Technical services:

1. Provide service of a factory trained service engineer, upon completion of equipment installation, for start-up and check out the equipment and instructing the operating personnel.

1.3 SUBMITTALS

**SUPERVISORY CONTROL AND DATA ACQUISITION SYSTEM
13310-2**

- A. Comply with pertinent provisions of Section 01340.
- B. Product data: Within 30 calendar days after the Contractor has received the Owner's Notice to Proceed, submit:
 - 1. Component manufacturing data sheets indicating pertinent data and identifying each component by item number and nomenclature as indicated on the drawings and in the specifications.
 - 2. Component drawings showing dimensions, mounting and external connection details.
 - 3. System wiring schematics, each on a single drawing with full description of operation. Component identification on the schematic shall be as indicated above.
- C. Provide operation and maintenance manuals complying with provisions of Section 01650.
 - 1. Additional requirements for manuals will be found in Part 2 of this Section of the Specifications.

1.4 PRODUCT DELIVERY, HANDLING AND STORAGE

- A. Comply with pertinent provisions of Section 01640.
- B. Schedule the delivery of the equipment to coordinate with the project completion schedule.
 - 1. Each item of equipment shall be tagged with identifying number shown on the Shop Drawings.
- C. Contractor's attention is directed to the fact that equipment has delicate components and extreme care shall be taken in handling and storage to avoid internal and/or external damages.
- D. Damaged equipment will not be accepted.
- E. Equipment not for immediate use shall be stored inside a building, with enclosures under protective coverings and shall be fully protected from moisture, extreme heat and vibration.

1.5 WARRANTY

- A. Comply with pertinent provisions of Section 01650.

PART 2 - PRODUCTS

2.1 GENERAL

- A. The total control and monitoring system consists of a series of individual control and monitoring loops, each configured to perform a specific function associated with the total plant flow scheme.

- B. Each loop consists of field and panel mounted analog hardware components along with computer software functions as required to perform the control and monitoring operations described in the individual loop descriptions.

2.2 SCADA FUNCTIONAL DESCRIPTIONS

A. General:

- 1. The new RTUs shall be configured for the inputs/outputs as described in the RTU Table shown on the drawings.

B. The RTU-1 pump VFD control sequence and interlocks are described below:

- 1. Local Manual Control (from VFD)
When the Hand-Off-Remote switch at either VFD is in the HAND position, the pump is started on demand. Speed is varied by the speed potentiometer on the front of the VFD.
- 2. Remote Manual Control (from the WTP SCADA system)
When the Hand-Off-Remote switch at either VFD is in the REMOTE position and the Hand-Off-Auto switch at the WTP SCADA HMI is in the Hand position, the pump is started on demand. Speed is varied by the HMI speed controller. Only one pump is permitted to run at a time.
- 3. Remote Auto Control (from the WTP SCADA system)
When the Hand-Off-Remote switch at either VFD is in the REMOTE position and the Hand-Off-Auto switch at the WTP SCADA HMI is in the Auto position, the pump is controlled based a flow setpoint, entered by the user. The plant raw water flow is used as a feedback signal. The pumps shall alternate after each run cycle. The run cycle shall be confirmed with the Owner.

C. The RTU-2 pump VFD control sequence and interlocks are described below:

- 1. Local Manual Control (from VFD)
When the Hand-Off-Remote switch at either VFD is in the HAND position, the pump is started on demand. Speed is varied by the speed potentiometer on the front of the VFD.
- 2. Local Manual Control (from RTU touchscreen)
When the Hand-Off-Remote switch at either VFD is in the AUTO position and the Hand-Off-Auto switch at the touchscreen is in the Hand position, the pump is started on demand. Speed is varied by the touchscreen. Only one pump is permitted to run at a time.
- 3. Local Auto Control (from RTU touchscreen)

When the Hand-Off-Remote switch at either VFD is in the REMOTE position and the Hand-Off-Auto switch at the touchscreen is in the Auto position, the pump is controlled based a pressure setpoint, entered by the user. The new pressure transmitter is used as a feedback signal. The pumps shall alternate after each run cycle. The run cycle shall be confirmed with the Owner.

4. Remote Monitoring (Cellular via alarm panel)
The pumps and pressure transmitter can be monitored via a cellular device. Confirm control functions with Owner.

C. See the I/O table for other functional requirements.

2.3 PROGRAMMABLE LOGIC CONTROLLERS (PLC's)

A. General Requirements.

1. It is the intent of these specifications to establish minimum requirements for a solid-state programmable logic controller-based I/O subsystem designed to provide high reliability for this application.
2. PLC-based I/O Subsystems shall be supplied for locations as noted in these specifications and as shown on the plans.
3. The internal wiring of the controller is to be fixed, with the logic functions it must perform in a given application to be programmed into its memory.
4. The controller shall be supplied with the CPU, communication cards, digital and analog input cards, digital and analog output cards, memory, power supply, and all power and interface cables necessary to function as a complete and operable programmable logic controller system.

B. PLC-based Panels

1. Programmable logic controllers (PLCs) for the new PLC shall be Schneider Electric M340 series with hardware as specified below unless noted otherwise.

C. The following is included as a guideline. It shall be the Control System Integrator's responsibility to visit each site to determine exact installation requirements.

RTU	Description and Enclosure	Location	Wired I/O	Notes
RTU-1	New NEMA 12 with PLC, Schneider	Electrical Room	See Schedule	
RTU-2	New NEMA 12 with PLC, Schneider and industrial computer	Electrical Room	See Schedule	

A. Cabinets and enclosures:

1. Provide cabinets with hinged doors for easy access.
2. Enclosures for PLC-based I/O sub-systems that shall be mounted in non-hostile indoors environments shall be of NEMA 12 construction (painted carbon steel) or as specified above.

D. PLC Enclosure Internal Panel Wiring and General Construction:

1. All PLC equipment shall be supplied with power supplies suitable for operation on 120 Volt, 60 Hertz, single-phase, AC power.
2. Receptacles with isolated ground shall be supplied for computer devices in the control room and internal to the PLC enclosures.
3. All field wiring terminations shall be made to terminal strips capable of accommodating up to #12 AWG wire. Terminal strips shall be mounted using DIN rails. Terminal strips shall be as manufactured by Phoenix, Square D, Allen-Bradley, or approved equal.
4. All analog inputs and outputs, including all spare analog inputs and outputs, shall be protected from surges using three separate levels of surge/transient suppression. The first level of protection shall be via a 1/4 Amp 3AG size fast acting fuse. Secondary and tertiary protection shall be fulfilled using combination gas discharge and metallic oxide varistor (MOV) surge protection with current limiting resistors. Terminals shall be installed to allow each of the four analog inputs to be configured for 2-wire or 4-wire process transmitters and to produce either 4 to 20 mA or 1 to 5 VDC outputs to the PLC and any future display or signal conversion devices. Terminals shall be installed adjacent to each spare analog surge protector to provide 24 VDC for connections of future 2-wire transmitters. Spare analog inputs and outputs shall be wired to analog surge protection, fuses, etc. and shall be ready to accommodate future field signals.
5. All digital inputs, including spare digital inputs, shall be isolated via interposing relays. Minimum contact rating for relays shall be 10 Amps at 250 VAC, minimum. Digital inputs shall be connected to field wiring via DIN rail mounted terminal strips. A 2 Amp 3AG size fuse shall protect digital inputs. Spare digital inputs shall be fully wired complete with relay isolation and terminal strips to accommodate future field signals.
6. All digital outputs, including spare digital outputs, shall be isolated from field wiring through terminal strips and electro-mechanical relays with contact ratings of 10 Amps at 250 VAC, minimum. Spare digital outputs shall be fully wired complete with relay isolation and terminal strips to accommodate future field signals.
7. Separate DC power supplies shall be provided for the PLC, analog I/O field supply, and digital I/O field supply. All DC power supplies shall be protected via indicating 3AG size fast acting fuses. Indicating fuse holders shall be DIN rail mounted.
8. A LED light (24" minimum) shall be mounted in the top of each PLC enclosure. The light shall be wired to a 2-pole limit switch that shall be mounted on the door of the PLC enclosure. When the door is opened, the light will automatically be turned on. When the door is closed, the light will automatically be turned off. The second pole of the limit switch shall be wired to a non-relay-isolated input of the PLC to provide a panel intrusion signal to the SCADA system.
9. Surge protectors shall be provided internal to the PLC enclosure to provide

- communications signal transient and surge protection.
10. Uninterruptible power supplies shall be furnished and installed inside each PLC enclosure and shall be sized to provide at least 15 minutes of backup power for the entire PLC enclosure. UPS systems shall be designed to provide transfer to backup power in the event of AC power failure without interrupting or halting the PLC processor. Provide line-interactive uninterruptible power supply system with 8-outlets and Smart-UPS Bundle.
 11. A minimum of two (2) circuit breakers shall be provided integral to the PLC enclosure. One circuit breaker shall provide protection to the PLC's internal power supplies and the other circuit breaker shall provide protection to a Ground Fault Interrupt (GFI) duplex utility outlet.
 12. A Square D AC power surge protector shall be installed integral to the PLC to provide transient and surge protection for incoming AC power. A separate 20 amp GFI duplex utility outlet shall be protected by the surge protector and shall be used only for the UPS system.

2.4 NETWORK

- A. All parts and installation shall meet or exceed EIA/TIA 568 standards, National Electrical code standards, category 6 compliant; and all materials and equipment must be guaranteed to be new. All cable runs are to be bi-directionally tested and certified with written test results per run. It is required that the installed system must meet or exceed 100 MB data rate performance.
- B. All cable, unless otherwise specified is to be category 6, 4 pair UTP with appropriate jacket; jacket is to be labeled as verified category 6, UL rated, and plenum or non-plenum. All patch cables are to be factory manufactured.
- C. All connectors are to conform to T56B designated pin/pair assignments.
- D. All station outlets are to be modular in design and contain two (2) wired 8 pin/8 conductor outlets. All jacks are to be stamped "Cat 6" or "Category 6" on the jack surface. Faceplates are to be ivory and flush mounted. See drawings for locations.
- E. Instrumentation and Control System Integrator to provide drawings and schematic of installed network showing physical cable layout, components, and node locations with numbered pin-outs.
- F. Provide Ethernet switches as required to interface with equipment specified and capable of connecting to the provided fiber-optic cable for communications with the SCADA network.

2.5 FIBER OPTIC ETHERNET SWITCH

- A. Fiber optic ethernet switch shall be Antaira or equivalent, 10/100 Mbps auto-sensing.

2.6 FIBER OPTIC CABLE/TERMINATIONS

- A. Fiber Optics Cable, Connectors, and Installation Hardware:
 - 1. Fiber Optics Cable: Fiber optics cable shall be 62.5/125 micron 12-fiber, loose-tube outdoor, with dry block altos LST. Fiber optics cable shall be Siecor 012KS4-14130A20 or equal of Siemens.
 - 2. Fiber Optics Interconnect Box: For each location where fiber optics terminations are to be made a panel-mountable interconnect center shall be provided to provide strain relief and protection for up to 12 fiber terminations via ST-style adapters. The wall-mounted fiber optics interconnection box shall be Siecor # WIC-012 for indoor applications complete with connector panels with ST adapters. Provide one box for each cable.
 - 3. Fiber Optics Jumpers: Jumpers between the fiber optics interconnect box and the transceiver shall be 2-fiber, 62.5/125 micron prefabricated jumper cable assemblies with ST-type connectors. Length of fiber optics jumpers shall be determined by Instrumentation and Control System Integrator.
 - 4. Fiber Optics Connectors: Fiber optics connectors shall be Siecor ST UNICAM type with ceramic tip for 62.5/125-micron fiber.
 - 5. Terminations: All fiber optics terminations shall be the responsibility of the Instrumentation and Control Systems Integrator.

2.7 INTERCONNECTING CABLES

- A. The Instrumentation and Control System Integrator shall furnish all cables required for interconnections between the computer system and all peripherals.
- B. The Instrumentation and Control System Integrator shall furnish all Ethernet cables and all associated fiber optics cables and parts including WIC fiber optics cable interface boxes, fiber optics connectors, fiber optics cable termination kits, etc. See specifications for details of fiber optics cable, connectors, etc.

2.8 FACTORY TESTING

- A. Not required.

2.9 COMPUTER SOFTWARE

- A. Georgetown-Update the computer graphics and controls to indicate new I/O.

2.10 INSTRUCTION MANUALS

- A. Provide a digital operations and maintenance manuals.
- B. Operating instructions to incorporate a functional description of the entire system including the "as-built" system schematics.
- C. Include and clearly define special maintenance requirements particular to the system along with special calibration and test procedures.

2.11 SOFTWARE DOCUMENTATION

- A. Provide complete documentation for operation and maintenance, covering both operating system software and application software in digital format.

2.12 DRAWINGS

- A. Provide "as-builts" drawings containing all necessary information for proper maintenance and system operation to include updating the plant system configuration diagram.
- B. Interconnection information between system components; and system components and packaged equipment found in other sections of these specifications, shall be complete with all necessary interconnection information.
 - 1. Notes referring to equipment manufacturer's drawings for proper interconnection will not be acceptable.
- C. Systems manufacturers to be responsible for furnishing the drawings.

PART 3 - EXECUTION

3.1 SURFACE CONDITIONS

- A. Examine the areas and conditions under which work of this Section will be performed. Correct conditions detrimental to timely and proper completion of the work. Do not proceed until unsatisfactory conditions are corrected.

3.2 INSTALLATION

- A. Coordinate as required with other trades to assure proper and adequate provision in the work of those trades for interface with the work of this Section.
- B. Install the work of this Section in strict accordance with the original design and the manufacturer's recommended installation procedures as approved by the Engineer, anchoring all components firmly into position for long life under hard use.
- C. Perform all wiring in compliance with NEC.

3.3 TRAINING

- A. Provide one 2 hour training session on the PLC equipment.
- B. Provide one 2 hour training session on the HMI modifications.

3.4 START-UP SERVICES

- A. Upon final completion of all components determine date of start-up jointly with Engineer, Owner and Contractor.

- B. The Instrumentation and Control System Integrator shall be responsible for placing SCADA equipment and systems in operation.
- C. The Instrumentation and Control System Integrator shall provide qualified personnel on the job site until successful completion of the required 30-day operational period for the new plant equipment. The SCADA system must perform successfully during the 30-day operational period.

END OF SECTION

**SECTION 16260
STANDBY ELECTRIC POWER SYSTEM**

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Work included: Furnish and install the engine driven standby electric generator system where shown on the Drawings, as specified herein, and as needed for a complete and proper installation including, but not necessarily limited to:
1. Diesel engine.
 2. Engine instruments and controls.
 3. Alternator.
 4. Control panel.
 5. Exhaust silencer.
 6. Weather-protective, sound attenuated, non- walk-in enclosure.
 7. Associated accessories and other items and services required to complete the system whether particularly mentioned or not.
 8. Fuel tank (filled on site-by contractor).
 9. Automatic transfer switch (specified in Section 16400).
- B. Related work:
1. Documents affecting work of this Section include, but are not necessarily limited to, General Conditions, Supplementary Conditions and Sections in Division 1 of these Specifications.
 2. Section 09900 - Painting.
 3. Section 16400 – Electrical.
- C. Applicable Standards
1. NFPA 70: National Electrical Code
 2. NFPA 110: Standard for Emergency and Standby Power Systems
 3. UL508: Standard for Industrial Control Equipment
 4. UL2200: Standard for Stationary Engine Generator Assemblies
 5. UL142: Standard for Steel Aboveground Tanks for Flammable and Combustible Liquids
 6. CSA C22.2 No. 14: Industrial Control Equipment
 7. CSA C282: Emergency Electrical Power Supply for Buildings
 8. CSA C22.2 No. 100: Motors and Generators
 9. EN61000-6: Electromagnetic Compatibility
 10. EN55011: Limits and Methods of Measurement of Radio Disturbance Characteristics of Industrial, Scientific and Medical (ISM) Radio-frequency Equipment
 11. FCC Part 15 - Radio Frequency Devices - Subpart B-Unintentional Radiators
 12. ISO 8528: Reciprocating Internal Combustion Engine Driven Alternating Current Generating Sets
 13. IEC 61000: Electromagnetic Compatibility

1.2 QUALITY ASSURANCE

- A. Use adequate numbers of skilled workmen who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the work of this section.
- B. Referenced manufacturer is Caterpillar and is named to establish standards of quality. Equal products by Cummins/Onan, Kohler or Generac conforming to these specifications may be provided as outlined in the bid form and as approved by the Engineer.

- C. The system shall be factory assembled and tested by the manufacturer of the generating system or be assembled and tested by an authorized representative of the manufacturer using an engine or generator made by the system manufacturer so that the system will have one source of supply and responsibility. The performance of the generating set series shall be certified by an independent testing laboratory as to the set's full power rating, stability and voltage and frequency regulation.
- D. The manufacturer of the generating system shall maintain a thoroughly stocked authorized parts and service facility within 150 miles of the installation.
- D. Technical services:
 - 1. Provide a service engineer, complying with requirements of Section 01660 to complete the initial start-up, make proper and complete adjustments of all adjustable devices, load switches, etc., and to also verify and approve all connections prior to any test operation of said equipment.
 - a. One 2-day trip.
 - 2. Confirmation in writing by the manufacturer's authorized representative of said services shall be submitted to Engineer.

1.3 SUBMITTALS

- A. Comply with pertinent provisions of Section 01340.
- B. Product data: Within 30 calendar days after the Contractor has received the Owner's Notice to Proceed, submit:
 - 1. Materials list of items proposed to be provided under this Section.
 - 2. Manufacturer's specifications and other data needed to prove compliance with the specified requirements.
 - 3. Shop Drawings in sufficient detail to show fabrication, installation, anchorage, and interface of the work of this Section with the work of adjacent trades.
 - 4. Manufacturer's recommended installation procedures which, when approved by the Engineer, will become the basis for accepting or rejecting actual installation procedures used on the Work.
- C. Upon completion of the work of this Section, and as a condition of its acceptance, deliver to the Engineer five copies of an operation and maintenance manual compiled in accordance with the provisions of Section 01650 of these Specifications.

1.4 PRODUCT HANDLING

- A. Comply with pertinent provisions of Section 01640.

1.5 WARRANTY

- A. Comply with provisions of Section 01650 and the following.
- C. Provide a standard two-year warranty on all labor, materials, and equipment of the generating system.
 - 1. Upon placing the generator in service provide a 30-day initial operating period.
 - 2. The warranty will begin upon successful completion of the initial operating period.

1.6 RULES AND PERMITS

- A. The entire installation shall be in accordance South Carolina Department of Health and Environmental Control (SCDHEC) Regulations, NFPA, and all local codes.

- B. The Engineer will obtain all permits and inspections required by local or state laws.
- C. Furnish the Owner with certificate of inspection and final approval from all authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Provide new and current system equipment consisting of:
 - 1. Engine driven electric generating set to provide standby power.
 - 2. Engine start-stop control system mounted on the generating set.
 - 3. Mounted accessories as specified.

2.2 SYSTEM

- A. Provide generator rated for continuous standby service as noted below at 0.8-power factor, 277/480 volt, 3-phase, 4-wire wye. Continuous standby service constitutes full load operation without interruption for a minimum period of 14 days.
 - 1. Raw Water Pump Station- 200 KW, 250 KVA

2.3 ENGINE

- A. Provide fuel filter and fuel transfer pump at engine.
- B. Provide water-cooled with mounted radiator, fan and water pump.
- C. Provide intake and exhaust valves made of heat resisting alloy steel with exhaust valve seat inserts.
- D. Supply full pressure lubrication by lube oil pumps.
- E. Provide air cleaner, fuel and oil filters with replaceable elements, and lube oil cooler.
- F. Govern engine speed by electronic governor to maintain the alternator frequency within one (1) hertz from no load to full load alternator output.
- G. Provide remote, 2-wire starting by a solenoid shift, electric starter.
- H. Directly connect the starter to the engine flywheel housing.

2.4 ALTERNATOR

- A. Provide brushless, 4-pole, revolving field design with temperature compensated solid-state voltage regulator and rotating rectifier exciter system.
 - 1. Provide rotor driven through a semi-flexible driving flange to ensure permanent alignment.
 - 2. Provide alternator with frequency regulation not exceeding 3 Hz from no load to rated load.
 - 3. Provide alternator with voltage regulation within +/-2% of rated voltage, from no load to full rated load.
 - 4. Provide alternator with recovery to stable operation occurring within 2 seconds.
 - a. Stable operation is defined as operation with terminal voltage remaining constant +/-1% of rated voltage.
 - 5. Provide alternator with a rheostat providing a minimum of +/-5% voltage adjustment from rated value.
 - 6. Provide alternator with temperature rise within NEMA MG1-22 definition.

7. Provide alternator utilizing 3-phase filtered sensing voltage regulation and having an independent power supply for the excitation system (i.e. permanent magnet generator, Auxiliary Winding, Regulator Exciter Principle (AREP) and series boost type excitation system).
8. Provide alternator with a sub-transient reactance of 0.12 per unit, or lower, based on steady-state rating.
9. Provide alternator with Class H insulation.
10. Provide alternator producing a voltage waveform for proper operation of variable frequency PWM drives that produce line to neutral total harmonic distortion to 5% maximum with a maximum 3% distortion in any single harmonic order.

2.5 CONTROLS

- A. Provide a fully solid-state, microprocessor based, generator control panel wired, tested and shock mounted on the generating set by the manufacturer of the generating plant.
- B. Provide the following functionality integral to the control panel:
 1. A minimum 64 x 240 pixel (28mm x 100mm) white backlight graphical display with text based alarm/event descriptions.
 2. A minimum of 3-line data display.
 3. Audible horn for alarm and shutdown with horn silence switch.
 4. Standard ISO labeling
 5. Multiple language capability
 6. Remote start/stop control
 7. Local run/off/auto control integral to system microprocessor
 8. Cooldown timer
 9. Speed-adjust
 10. Lamp test
 11. Push button emergency stop button
 12. Voltage-adjust
 13. Voltage regulator V/Hz slope – adjustable
 14. Power Factor Control for paralleling units
 15. Password protected system programming
- C. Provide the panel with the following Digital indications:
 1. AC voltage, 3-phase (L-L and L-N)
 2. AC amps (3-phase and total)
 3. KW (total and per phase)
 4. KVA (total)
 5. KVAR (total)
 6. KWHR (total)
 7. KVARHR (total)
 8. PF (average total and 3-phase)
 9. % of rated (total)
 10. Frequency
 11. DC voltage
 12. System diagnostic
 13. Excitation voltage
 14. Excitation current
 15. Engine oil pressure
 16. Engine oil temperature
 17. Engine coolant temperature
 18. Engine RPM
 19. Battery volts
 20. Engine hours
 21. Engine crank attempt counter
 22. Engine successful start counter
 23. Service maintenance interval

24. Real time clock
 25. Oil filter differential pressure
 26. Fuel temperature
 27. Fuel pressure
 28. Fuel filter differential pressure
 29. Fuel consumption rate
 30. Total fuel consumed
 31. Engine intake manifold temperature
 32. Engine intake manifold pressure
 33. Engine crankcase pressure
 34. Air filter differential pressure
 35. Boost pressure
 36. Oil filter differential pressure
- D. Provide alarm indication and subsequent shutdown for the following conditions (Store in the control panel the first and last occurrences of all alarms and shutdowns with a time, date, and engine hour stamp):
1. Low oil pressure alarm/shutdown
 2. High coolant temperature alarm/shutdown
 3. Loss of coolant shutdown
 4. Overspeed shutdown
 5. Over-crank shutdown
 6. High intake manifold temperature alarm/shutdown
 7. High exhaust manifold temperature alarm/shutdown
 8. High crankcase pressure alarm/shutdown
 9. High air inlet temperature alarm/shutdown
 10. Emergency stop depressed shutdown
 11. Low coolant temperature alarm
 12. Low battery voltage alarm
 13. High battery voltage alarm
 14. Control switch not in auto position alarm
 15. Battery charger failure alarm
 16. Generator over voltage
 17. Generator under voltage
 18. Generator over frequency
 19. Generator under frequency
 20. Generator reverse power
 21. Generator overcurrent
 22. Loss of excitation alarm/shutdown
 23. Instantaneous over excitation alarm/shutdown
 24. Time over excitation alarm/shutdown
 25. Rotating diode failure
 26. Loss of sensing
 27. Loss of PMG
- E. Provide the ability to accept six (6) programmable digital input signals.
- F. Provide accessible through a single electronic service tool all engine, voltage regulator, control panel and accessory units. Provide the following maintenance functionality:
1. Engine running hours display
 2. Service maintenance interval (running hours or calendar days)
 3. Engine crank attempt counter
 4. Engine successful starts counter
 5. 20 events are stored in control panel memory
 6. Programmable cycle timer that starts and runs the generator for a predetermined time. The timer shall use 14 user-programmable sequences that are repeated in a 7-day cycle. Each sequence shall have the following programmable set points:

- a. Day of week
 - b. Time of day to start
 - c. Duration of cycle
- G. Provide Modbus RTU remote communications as standard via RS-485 half duplex with configurable baud rates from 2.4k to 57.6k.
- H. Provide an annunciator to meet the requirements of NFPA 110, Level 1.
- 1. Network directly to the generator set control
 - 2. Include a lamp test pushbutton, alarm horn and alarm acknowledge pushbutton
 - 3. Provide the following individual light indications for protection and diagnostics:
 - a. Overcrank
 - b. Low coolant temperature
 - c. High coolant temperature warning
 - d. High coolant temperature shutdown
 - e. Low oil pressure warning
 - f. Low oil pressure shutdown
 - g. Overspeed
 - h. Low coolant level
 - i. EPS supplying load
 - j. Control switch not in auto
 - k. High battery voltage
 - l. Low battery voltage
 - m. Battery charger AC failure
 - n. Emergency stop
 - o. Spare
 - p. Spare
- J. Equip unit with factory mounted terminal blocks and strips for all power, signal and control wiring connections.
- K. Provide dry contacts configured to monitor generator running, generator alarm, generator low fuel and 4-20mA signal to monitor fuel level.

2.6 GENERATING SET MOUNTING

- A. Equip generator set with vibration isolators and mount on a welded steel base that will provide suitable mounting to any level surface.
- B. Equip unit with a reinforced sheet steel, minimum 16-gauge, sound attenuating, non-walk-in weather-protective housing.
- 1. Reinforce to be vibration-free in the operating mode.
 - 2. Provide housing with lockable removable panels on each side of the housing to access generator with a hinged door to access instrument panel.
 - 3. Provide housing complete with accessories listed below, be rust treated and painted standard color of manufacturer.
 - 4. Provide peaked roof for drainage.
 - 5. Provide corrosion resistant fasteners.
 - 6. Extend coolant and oil drain line connections outside of enclosure.
 - 7. Insulate enclosure to limit unit noise to 85 db at 23'.
 - 8. Mount enclosure over an integral welded steel base fuel tank complete with all fuel fittings, level indicator, vent, exterior lockable fill port and drains, etc., and necessary galvanized steel support framing so that the weight of the generator is not supported by the tank. Size tank to run the generator at full load for a minimum of 2 days.
 - a. Enclose tank in a welded steel secondary containment vessel having an audible spill alarm system powered from the generator battery system and alarmed on the generator control panel.

- b. All welds, cuts, openings, etc., in the steel material, shall be cold galvanized as a minimum after fabrication.
9. Provide tank underwriter's labeled (UL).

2.7 ACCESSORIES

- A. Provide the plant with all accessories needed for proper operation to include, but not be limited to:
 1. A residential type silencer of carbon steel painted with high heat silver paint mounted inside enclosure.
 2. Stainless steel flexible exhaust connection.
 3. Sufficient exhaust piping of 316 schedule 40 stainless steel pipe and fittings, including end rain cap.
 4. Lace-up type insulation blankets to completely insulate muffler and interior exhaust piping.
 5. Provide a 10-amp, automatic "float" type battery charger to maintain the batteries at normal capacity.
 - a. Provide 120V input with 12 VDC output to battery(s)
 - b. Provide cables, battery rack, AC compensation, current limit, DC ammeter to show battery voltage, equalizing switch, fused AC input and DC output, complete isolation of AC input and DC output.
 - c. Design as not to discharge the battery in event of failure.
 6. Provide engine mounted, thermostatically controlled, immersion type heater to ensure a minimum coolant temperature of 120° F in a minimum ambient temperature of -15° F.
 - a. Operate on a 120-volt, single-phase AC power.
 7. Engine Block Heaters sized per manufacturer's requirements. Any required increase of feeder circuits, different from that as shown on drawings, is the responsibility of the Contractor to provide and install at no additional cost to the Owner.
 8. Shore power to generator ton generator shall consist of 1-30A, 208-volt single phase circuit.
- B. Design and provide anchor bolts for anchorage of generator system to the concrete foundation. Provide either stainless steel cast-in anchors or stainless steel post-installed adhesive anchors. Design anchorage to concrete foundations per ACI 318 -14, Chapter 17, assuming concrete is cracked and has a 28-day compressive strength of 4500 psi, and assuming no supplementary reinforcement is present in the foundations.
- C. Radiator coolant shall be all weather, all season, environment friendly 50% solution antifreeze.
- D. Provide adequate fuel to fill tank (by Contractor)
- E. Overcurrent Protection:
 1. Furnish the engine/generator set with overcurrent output protection per the latest edition of NEC 445-4 at the engine/generator set.

2.8 IDENTIFYING SIGNS

- A. Provide identifying signs as shown on drawings and as specified herein for proper installation and in accordance with latest edition of National Electrical Code.
 1. Sign design is based on use of standard products manufactured by Seton Name Plate Company of New Haven, CT and is named to establish standards of quality.
 2. Provide the products upon which design is based or provide equal products of another manufacturer approved in advance by the Engineer.
 3. Provide sign material as 60 mils. thick press polished high-performance vinyl plastic.

4. Provide sunlight fade resistance.
5. Overcoat with Tedlar.
6. Provide rounded corners.
7. Provide 14" x 10" sign.
8. Main heading to read: "CAUTION", white letters on red background with black border. Subtitle to have black letters on white background.
9. Mount with stainless steel screws at location as directed in field.
10. Sign schedule:

<i>AREA</i>	<i>SIGN SUBTITLE</i>	<i>NO. SIGNS PER AREA</i>
Service Entrance	Standby Emergency Generator Onsite	1
System Ground Connection Point	Normal Service and Standby Emergency Generator Connected to Grounding Electrode	1

11. Install sign in strict accordance with the manufacturer's recommendations as approved by the Engineer, using only the approved mounting materials, and locating all components firmly into position, level and plumb.
12. Locate where directed by the Engineer.
13. Mounting hardware to be Type 316 stainless steel.
14. Where adequate sign supports are not available, fabricate sign stand using Type 316 stainless steel channel and fittings.

PART 3 - EXECUTION

3.1 SURFACE CONDITIONS

- A. Examine the areas and conditions under which work of this Section will be performed. Correct conditions detrimental to timely and proper completion of the Work. Do not proceed until unsatisfactory conditions are corrected.

3.2 INSTALLATION

- A. Coordinate as required with other trades to assure proper and adequate provision in the work of those trades for interface with the work of this Section.
- B. Install the work of this Section in strict accordance with the manufacturer's recommendations as approved by the Engineer.
- C. Put all components through at least five complete cycles of operation, adjust as required, and verify that the complete system functions at optimum operating level.
- D. The Contractor shall be responsible for the fuel for the testing and start-up of the generator sets. They shall also fill the tanks once all start-up and testing is completed (prior to placing into service).

3.3 TESTING AND INSPECTION

- A. Provide personnel and equipment, make required tests, and secure required approvals from the Engineer and governmental agencies having jurisdiction.
- B. The Contractor shall make written notice to the Engineer adequately in advance of each of the following stages of construction:
 - 1. In the underground condition prior to placing concrete floor slab, when all associated electrical work is in place.
 - 2. When all rough-in is complete, but not covered.
 - 3. At completion of the work of this Section.
- C. An operational test of the standby power system shall be conducted by a representative of the manufacturer of this equipment in the presence of the Engineer and the operating personnel. It shall be demonstrated during these tests that the voltage sensitive and time delay devices perform at their specified settings.
- D. Perform a 2-hour load bank test at 1.0 power factor at full nameplate load using a resistive load bank and cables supplied by the manufacturer's representative. Provide test equipment and fuel at no additional cost to the Owner. Observe and record the following data at 15-minute intervals:
 - 1. Service meter hours.
 - 2. Volts AC - All phases.
 - 3. Amps AC - All phases.
 - 4. Frequency.
 - 5. Power factor or VARs.
 - 6. Jacket water temperature.
 - 7. Oil pressure.
 - 8. Fuel pressure.
 - 9. Ambient temperature.
- E. When material and/or workmanship are found to not comply with the specified requirements, within three days after receipt of notice of such non-compliance remove the non-complying items from the job site and replace them with items complying with the specified requirements, all at no additional cost to the Owner.

3.4 PROJECT COMPLETION

- A. Upon completion of the work of this Section, the Contractor shall thoroughly clean all exposed portions of the system installation, removing all traces of soil, labels, grease, oil and other foreign material, and using only the type cleaner recommended by the manufacturer of the item being cleaned.
- B. Thoroughly indoctrinate the Owner's operation and maintenance personnel in the contents of the operations and maintenance manual required to be submitted under Part 1.3 of this Section of these Specifications.

END OF SECTION

SECTION 16400 ELECTRICAL

PART 1 – GENERAL

1.1 DESCRIPTION

- A. Work included: Provide a complete electrical system as indicated on the Drawings, as specified herein, and as needed for a complete and proper installation including, but not necessarily limited to:
1. Main service, distribution equipment, and transformers.
 2. Feeder system, in conduit.
 3. Branch circuit panels for power and lighting.
 4. Branch circuit wiring, in conduit, for lighting, receptacles, junction boxes and motors.
 5. Hangers, anchors, sleeves, chases, supports for fixtures, and other electrical materials and equipment in association therewith.
 6. Lighting fixtures.
 7. Wiring system, in conduit, for equipment and controls provided under other Sections of these Specifications including, but not necessarily limited to, Equipment and Mechanical Sections.
 8. Motor starters, variable frequency drives and controls for motors provided under the Contract, but for which motor starters and controls are not otherwise provided.
 9. Automatic Transfer switches.
 10. Transient voltage surge suppressor.
 11. Other items and services required to complete the systems whether particularly mentioned or not.
- B. Related work:
1. Documents affecting work of this Section include, but are not necessarily limited to, General Conditions, Supplementary Conditions, and Sections in Division 1 of these Specifications.
 2. Section 16260 – Standby Electric Power System.

1.2 ABBREVIATIONS

A	Ampere (Amps)	LCCF	Lamp Current Crest Factor
AFF	Above Finished Floor	MCA	Minimum Circuit Amps
AFG	Above Finished Grade	MCC	Motor Control Center
AHJ	Local Authority Having Jurisdiction	MCM	1000 Circular Mills (KCMIL)
AIC	Amps Interrupting Current	MOCP	Maximum Over-current Protection
AFCI	Arc-Fault Circuit Interrupter	N	Neutral
ANSI	The American National Standards Institute	NEC	2002 National Electrical Code
BF	Ballast Factor	NEMA	National Electrical Manufacturers

			Association
Bkr.	Breaker	NFPA	National Fire Protection Association
C	Conduit	NIC	Not in Contract
Ckt.	Circuit	OSHA	Occupational Safety and Health Act
CRI	Color Rendering Index	PF	Power Factor
CU	Copper Conductor	PLC	Programmable Logic Controller
DETD	Dual Element Time Delay Fuse	PVC	Polyvinyl Chloride Conduit
Disc.	Disconnect	RGSC	Rigid Galvanized Steel Conduit
Dn	Down	RMS	Root Mean Square
EMT	Electrical Metallic Tubing	RTU	Remote Terminal Unit
FLA	Full Load Amps	SCADA	Supervisory Control and Data Acquisition
FPM	Fuse per Manufacturer Requirements	SCCR	Short-Circuit Current Rating
FS	Federal Specifications	SPD	Surge Suppression Device
G or Gnd.	Ground	Sym	Symmetrical
GFCI	Ground-Fault Circuit Interrupter	THD	Total Harmonic Distortion
GFP	Ground-Fault Protection	TSP	Twisted Shielded Pair
HD	Heavy Duty	TVSS	Transient Voltage Surge Suppressor
HP	Horsepower	UL	Underwriters Laboratories Inc.
IBC	International Building Code	UON	Unless Otherwise Noted
IEEE	The Institute of Electrical and Electronics Engineers	V	Volts
IMC	Intermediate Metallic Conduit	W	Watts
KVA	Kilovolt-Amps	WFC	Watertight Flexible Conduit
KW	Kilo Watt	WG	Wire Guard
KA	Kilo Amps	XFMR	Transformer

1.3 QUALITY ASSURANCE

- A. Use adequate numbers of skilled workmen who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the work of this Section. These shall include, but not be limited to, an electrical supervisor who is a licensed master electrician, a field foreman with a minimum journeyman electrician's license and adequate electricians and helpers.
- B. Without additional cost to the Owner, provide such other labor and materials required to complete the work of this Section in accordance with the requirements of governmental agencies having jurisdiction, regardless of whether such materials and associated labor are called for elsewhere in these Contract Documents.

1.4 SUBMITTALS

- A. Comply with pertinent provisions of Section 01340.
- B. Product data: Within 30 calendar days after the Contractor has received the Owner's Notice to Proceed, submit:

1. Materials list of items proposed to be provided under this Section.
2. Manufacturer's specifications, other data and shop drawings needed to prove compliance with the specified requirements. Provide the following approval drawings:
 - a. Automatic Transfer Switch
 - b. Main Breaker
 - c. Panels
 - d. Transformers
 - e. Wiring devices and cover plates
 - f. Conduit and fittings
 - g. Conductors
 - h. Lighting fixtures
 - i. Motor starters
 - j. Safety/Disconnect switches
 - k. Transient Voltage Surge Suppressor
 - l. Special systems
3. Manufacturer's recommended installation procedures which, when approved by the Engineer, will become the basis for accepting or rejecting actual installation procedures used on the Work.

C. Samples:

1. When so requested by the Engineer.
2. When specifically, so requested by the Contractor and approved by the Engineer, approved samples will be returned to the Contractor for installation on the Work.

D. Manual: Upon completion of this portion of the Work and as a condition of its acceptance, provide operation and maintenance manuals in accordance with the provisions of Section 01650 of these Specifications. Include within each manual:

1. Copy of the approved Record Documents for this portion of the Work.
2. Copies of all circuit directories.
3. Copies of all warranties and guaranties.

1.5 PRODUCT HANDLING

- A. Comply with pertinent provisions of Section 01640.

1.6 WARRANTY

- A. Provide standard one (1) year warranty on all labor and materials.
- B. Provide a five (5) year warranty on all LED fixtures.
- D. Provide minimum five (5) year warranty on Surge Protection Devices, incorporating unlimited replacements of suppressor parts if destroyed by transients during the warranty period.

- E. Provide standard five (5) year parts and labor warranty on automatic transfer switch.
- F. Comply with Section 01650.

1.7 RULES AND PERMITS

- A. The entire installation shall be in accordance with the latest edition of the NEC, OSHA, and all local codes.
- B. Apply and pay for all permits and inspections required by local or state laws.
- C. Furnish the Owner with certificate of inspection and final approval from all authorities having jurisdiction.

1.8 DRAWINGS

- A. The drawings and specifications are complementary to each other and what is called for by one shall be as binding as if called for by both. The drawings are diagrammatic and are to be followed as closely as the construction will permit.
- B. The drawings show the general location of outlets, conduits and circuit arrangement. Because of the small scale of the drawings, it is not possible to indicate all of the detail involved. The Contractor shall carefully investigate the structural and finish conditions affecting all his Work and shall arrange such work accordingly, furnishing such fittings, junction boxes and accessories as may be required to meet such conditions.

1.9 ELECTRICAL SERVICE

- A. From the utility company, establish requirements for transformer pad(s), metering, connections, etc., and make provisions for them; providing and installing all lugs, connectors, grounding, etc., required for a complete installation.
 - 1. Coordinate work with both the electric utility company and the Owner, and schedule the installation of the service in accordance with the construction schedule such that there will be no delays in equipment startup and placing the facilities in operation.
- B. Local Utility Company is the City of Georgetown. Contact Harry Johnson at hjohnson@georgetownsc.gov.

1.10 ELECTRICAL OUTAGE

- A. Coordinate all outages with the Owner, 72 hours prior. Schedule all outages such that they will not interfere with normal plant operation and that there will be no delays in equipment startup and placing the facilities in operation.

1.11 SPARE PARTS

- A. Provide the following spare parts to Owner in neatly packaged box marked with contents:

1. Keys: One (1) set of spare panelboard/switchboard keys with lists to Owner.
2. Fuses: One (1) box fuses for each type and size installed on the project.
3. Fuse Puller: One (1) fuse puller to Owner capable of removing all types of fuses installed on job.
4. TVSS: One (1) SPD protection module per unit as an on-site spare.

PART 2 – PRODUCTS

2.1 GENERAL

- A. Provide only materials that are new, of the type and quality specified. Where Underwriters' Laboratories, Inc. have established standards for such materials, provide only materials bearing the UL label. Materials called for are to be considered as standard that, however, implies no right on the part of the Contractor to substitute other materials and methods without written authority from the Engineer.
- B. Temporary power:
 1. In addition to providing temporary power as described in Section 01500 of these Specifications, provide and pay the costs for installing permanent electrical meter or meters.
 2. When all equipment is in place and connected, and the Engineer determines the project is ready for final checkout, arrange to have the permanent metering installed in the Owner's name. At this point, the Owner will be responsible for all charges.
- C. Where any material or operation is specified by reference to published specifications or standards or the specifications or standards of any other organization; the referenced specification or standard shall be as much a part of this Section as if quoted in full herein.

2.1 RACEWAYS

- A. Applicable Standards:
 1. ANSI C80.1: Rigid Steel Conduits, Zinc-Coated.
 2. ANSI C80.3: Electrical Metallic Tubing, Zinc Coated.
 3. ANSI C80.5: Rigid Aluminum Conduits.
 4. ANSI C80.6: Intermediate Metallic Conduits.
 5. ANSI/NEMA FB1: Fittings and Supports for Conduit and Cable Assemblies.
 6. UL 6: Rigid Steel Conduit – Zinc Coated.
 7. UL 651-2002: Schedule 40 PVC and schedule 80 Rigid PVC Conduit.
 8. UL 514B: Flexible conduit fittings.
 9. NEMA RN 1: Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit.
 10. NEMA FB 1: Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing and Cable.
 11. ASTM F512: Polyvinyl Chloride (PVC) Conduit.
 12. ASTM D870: Standard Practice for Testing Water Resistance of Coatings Using Water Immersion.
 13. ASTM D1151: Standard Practice for Effect of Moisture and Temperature on Adhesive Bonds.
 14. FS WW-C 581E: Federal Specification for Rigid Galvanized Steel Conduit.

15. FS-WW-C-563A: Federal Specification for Electrical Metallic Tubing.
 16. FS-WW-C-540C: Federal Specification for Rigid Aluminum Conduit.
 17. FS WW-C 566: Federal Specification for Flexible Metal Conduit.
- B. Acceptable Manufacturers:
1. Wheatland.
 2. Allied Tube.
 3. Perma-Cote; Division of Robroy.
 4. Ocal.
 5. Plasti-Bond
- C. Provide conduit and fittings conforming to the above standards.
- D. Rigid aluminum conduit:
1. Provide thread type fittings and conduit bodies with matching material.
 2. Provide standard electric conduit couplings
 - a. Do not use pipe couplings or sleeves.
 3. Provide full weight galvanized fittings.
 4. Do not imbed aluminum conduit concrete containing chlorides, unwashed beach sand, sea water, or coral bearing aggregates.
 5. Isolate from other metals with heat shrink tubing (Raychem or equal) or plastic-coated hangars.
 6. Use strap wrenches for tightening aluminum conduit.
 - a. Do not use Pipe wrenches, channel locks, chain wrenches, pliers, etc.
 7. Clean and coat all threads on aluminum conduit and fittings with "No-Oxide" compound before using.
 8. Completely cover Aluminum conduit installed in concrete or below grade with two(2) coats of bitumastic paint.
 9. Terminate aluminum conduit entering manholes and below grade pullboxes with grounding type bushings and connected to a 3/4" x 10" copperclad rod with a #6 bare copper wire.
 10. All risers from underground, concrete pads, floors, etc.
 - a. Provide heat shrink tubing (Raychem or equal) from a point 12 inches below bottom of slab or grade to a point not less than 6 inches above grade or surface of slab.
- E. Provide hot-dipped, galvanized, watertight type fittings for liquid tight flexible conduit as manufactured by O-Z/Gedney or approved equal. Provide PVC coated fittings for PVC coated rigid galvanized steel conduit installations.
- F. Conduit/Cable supports – properties:
1. Provide 316 stainless steel supports for all exposed metallic conduit as manufactured by Unistrut or approved equal.
 2. Provide one-hole, PVC coated, malleable iron conduit straps with back spacer for all PVC coated rigid aluminum conduit.
 3. Provide stainless steel strain relief and cable grips/supports for power cables. Tie each support of to the hanger support.
- G. All conduits to conform to the following specifications:
1. Installations under concrete slab: Schedule 80 PVC, elbow and riser shall be coated aluminum.
 2. Exposed outdoor locations: Rigid aluminum conduit.
 3. Exposed Interior locations: Rigid aluminum conduit.
 4. Installations in concrete-encased duct banks: Schedule 40 PVC.
 5. Installations underground exposed to earth: Rigid aluminum conduit with PVC or bitumastic coating.

2.3 CONDUCTORS

A. Applicable standards:

1. NEMA WC 3: Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy
2. NEMA WC 5: Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy
3. UL 44 – 2002: Rubber-Insulated Wires and Cables
4. UL 83 – 1999: Thermoplastic-Insulated Wires and Cables
5. UL 854 – 2002: Service Entrance Cables

A. Acceptable Manufacturers:

1. Okonite
2. Pirelli
3. Southwire
4. Superior Essex
5. Belden

C. Conductor types:

1. Low voltage conductors (0 to 600V)
 - a. For secondary service entrance, feeders, underground, under floor, in damp or wet locations, and to any process associated equipment provide copper, 600V, 90°C, Type XHHW.
 - b. For all other low voltage conductors, provide copper, 600V, 75°C, Type THWN.
 - c. Provide stranded conductors for sizes #12 and larger.
 - b. Provide stranded conductors for sizes #12 and larger.
 - c. Provide same type of equipment grounding conductors as specified above.
 - d. Analog Control/Communications (TSP) – Provide tinned copper, polyethylene insulated, twisted pair, aluminum-polyester, overall shield with 20-gauge drain.
 - e. Provide analog signal conductors sized as shown on drawings with minimum size of 18-gauge.
 - f. For all discrete signal conductors, provide copper stranded, 600V, Type THWN with a minimum size of #14, unless otherwise noted.
 - g. For all control conductors installed in underground conduits provide cable listed as suitable for direct burial.
2. Splices, Connections and Terminations (0 to 600V)
 - a. For #8 AWG, use solderless pressure connectors with insulating covers for copper wire splices and taps. Use insulated spring wire connectors with plastic caps for #10 AWG and smaller
 - b. Use insulated, mechanical connectors for copper wire splices and taps, #6AWG and larger, ILSCO or approved equal. Tape connectors with electrical tape to prevent moisture infiltration.

2.4 GROUNDING AND BONDING

A. Applicable standards:

1. UL 467-1998: Grounding and Bonding Equipment.
2. NFPA 70: National Electrical Code.
3. ANSI/IEEE 32: Requirements, Terms and Test Procedures for Neutral Grounding Devices.
4. IEEE 80: Guide for Safety in Substation Grounding.
5. IEEE 81: Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System.
6. NETA ATS: Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems (International Electrical Testing Associates).

B. Grounding electrodes (Rod type):

1. Acceptable Manufacturers:
 - a. LTV Copperweld.
 - b. Line Material.
2. Material: Copper-clad steel.
3. Diameter: $\frac{3}{4}$ ".
4. Length: 10'-0"
5. Type: Sectional.

C. Mechanical connectors:

1. Acceptable Manufacturers
 - a. Burndy.
 - b. Robbins.
 - c. Harger.
2. Material: Bronze.

D. Exothermically-welded connections:

1. Acceptable Manufacturers
 - a. Cadweld

E. Grounding Electrode Conductor:

1. Material: Bare, soft-drawn, stranded, copper
2. Minimum size: Meet NEC 70 requirements.

F. Bonding Material:

1. Material: Bare, soft-drawn, stranded, copper
 2. Minimum size: Meet NEC 70 requirements.
- G. Regulatory requirements:
1. Products: Listed and classified by UL as suitable for the purpose specified and indicated.
- H. Provide Ground-Fault Protection of service entrance disconnects 1000 amperes or more at 277/480V per NEC 70 Part 230-95. Refer to plans for additional locations or requirements.

2.5 TRANSIENT VOLTAGE SURGE PROTECTION

- A. Applicable standards:
1. UL 1449 Current Edition - transient Voltage Surge Suppressor.
 2. IEEE C62.41 - IEEE Recommended Practice on Surge Voltages in Low Voltage AC Power Circuits.
 3. IEEE C62.45 - IEEE Guide on Surge Testing for Equipment Connected to Low-Voltage AC Power Circuits.
 4. UL 67 - Panelboards (when mounted in panelboards).
 5. UL 891 - Dead-Front Switchboards (when mounted in switchboards).
 6. NEMA LS1 - National Electrical Manufacturer's Association – 1992, R2000.
 7. MIL STD. 220A - Test Methods of Insertion Loss.
- B. Acceptable Manufacturers:
1. Advanced Protection Technologies, Inc. (APT)
 2. American Power Conversion Corporation (APC)
 3. Eaton
 4. Square D
 5. Ditek
- C. Surge Suppression Device (SPD)
1. Manufacturer's published UL 1449 test results shall reflect SPD connected lead length of 6" or greater.
 2. Provide SPD devices with a minimum EMI/RFI filtering of -50dB at 100 kHz using MIL-STD-220A methodology.
 3. Provide a SPD unit with a short circuit current rating clearly marked and install at a point on the system where the available fault current is in excess of that rating.
 4. Provide dedicated circuit breaker/disconnect for the SPD.
 5. Provide SPD with one set of NO/NC dry contacts.
 6. Provide SPD with protection-indicating LED's that are visible without opening enclosure.
 7. Provide SPD that meets or exceeds the following criteria:
 - a. Maximum UL Suppression Voltage Rating (SVR) and Maximum Operating Voltage (MCOV):

System Voltage	L-N	L-G	N-G	L-L	MCOV
120/240V 1Ø Split Phase	700	700	700	1200	150
208/120V 3Ø	700	700	700	1200	150
480/277V 3Ø	1200	1200	1200	2000	320

b. Minimum Surge Capacity and modes of protection:

SPD Location	Modular Parallel Protection	Modes of Protection	RFI Filtering	Surge Capacity Per Phase
Service Entrance >200A, < 800A	Yes	L-N, N-G, L-G	Yes	200kA
Distribution Panel > 400A, < 800A	Yes	L-N, N-G, L-G	Yes	150kA
Distribution Panel ≤ 400A	No	L-N, N-G, L-G	No	100kA
Branch Circuit Panels > 200A	No	L-N, N-G, L-G	No	150kA
Branch Circuit Panels ≤ 200A	No	L-N, N-G, L-G	No	100kA

2.6 OUTLET BOXES

A. Applicable standards:

1. ANSI/NEMA OS 1: Sheet-steel Outlet Boxes, Device Boxes, Covers and Box Supports.
2. ANSI/NEMA OS 2: Nonmetallic Outlet Boxes, Device Boxes, Covers and Box Supports.
3. NEMA 250: Enclosures for Electrical Equipment (1000 Volts Maximum).
4. NEMA FB 1: Type FD, Cast Ferroalloy Boxes.
5. UL 508: UL Standard for Safety Industrial Control Equipment.

B. Types and properties:

1. Outlet boxes:
 - a. Sheet metal outlet boxes (ANSI/NEMA OS1; galvanized steel, with 1/2" male fixture studs where required).
 - b. Nonmetallic outlet boxes (ANSI/NEMA OS2)
 - c. Cast boxes (NEMA FB1; deep type, gasketed cover, threaded hubs).

C. Pull and junction boxes:

1. Sheet metal boxes:
 - a. Indoor location installations: Provide the type specified in ANSI/NEMA OS1 or 316 stainless-steel as shown on drawings.
 - b. Indoor location installations: Provide hinged-type enclosure for enclosures larger than 12 inches in any dimension.
2. Cast aluminum boxes:

- a. Outdoor and wet location installations: Conform to NEMA 250; Type 4 and Type 6, flat-flanged, surface-mounted junction box, UL listed as rain tight, cast aluminum box cover with ground flange, neoprene gasket, and stainless-steel cover screws as manufactured by Cooper Crouse-Hinds.
3. Non-metallic boxes:
 - a. Above ground location installations: Conform to UL 508, NEMA type as shown on drawings, molded fiberglass polyester, with removable hinged cover, neoprene gasket, and stainless-steel cover screws as manufactured by Hoffman.
 - b. In Ground location installations: Conform to UL 508, NEMA type as shown on drawings, pre-cast polymer concrete, with removable, heavy-duty bolted cover, and stainless-steel cover screws as manufactured by Strongwell.
- D. Outlet box schedule, unless otherwise noted:
1. Interior boxes:
 - a. Galvanized extensions and rings.
 - b. Ganged where two or more devices occur at the same location.
 - c. One-piece type.
 - d. Studs for lighting fixtures, when required.
 - e. Lugs or ears to secure covers or plaster rings.
 - f. As required, covers or plaster rings.
 - g. Small exposed boxes - galvanized cast type with hubs.
 - h. Large exposed and exterior boxes - NEMA 4X type.
 2. Ceiling boxes, minimum 4"x 4" x 2-1/8" deep, or 4" octagon x 2-1/8" deep, of one-piece construction, except where otherwise specified herein or when larger size is required by code.
 3. Provide masonry type boxes in block walls.
 4. Provide concrete type in poured slabs.
 5. Provide non-metallic boxes for underground installations.
- E. Box locations:
1. Provide electrical boxes as shown on Drawings, and as required for splices, taps, wire pulling, equipment connections, and code compliance.
 - a. Electrical box locations shown on Contract Drawings are approximate unless dimensioned.
 - b. Verify the location of all boxes and outlets prior to rough in.
 - c. Locate the boxes to allow access.
 - d. Locate and install boxes such that headroom is maintained and a neat appearance is presented.

2.7 HANDHOLES

- A. Applicable standards:
 - 1. ANSI/SCTE 77: Specification for Underground Enclosure Integrity
 - 2. ASTM C1028: Standard Test Method for Determining the Static Coefficient of Friction of Ceramic Tile and Other Like Surfaces by the Horizontal Dynamometer Pull-Meter Method
 - 3. ASTM C478-03a" Standard Specification for Pre-cast Reinforced Concrete Manhole Sections
 - 4. ASTM A615: Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement

- B. Handholes
 - 1. Acceptable Manufacturers:
 - a. Quazite
 - 2. Provide 24" x 36" x 24" underground enclosures constructed of polymer concrete and tested to a minimum of 20,000 PSI, unless noted otherwise on plans.
 - 3. Provide enclosures with heavy-duty cover tested to a minimum of 20,000 PSI, having a minimum coefficient of friction of 0.50. Provide cover engraved with "Electric" or "Communications".
 - 4. Provide enclosures equal to Quazite PG series with HA type cover.

2.8 WIRING DEVICES

- A. Applicable standards:
 - 1. FS W-C-596: Electrical Power Connector, Plug, Receptacle, and Cable Outlet.
 - 2. FS W-S-896: Switch, Toggle.
 - 3. NEMA WD 1: General Purpose Wiring Devices.
 - 4. NEMA WD 2: Semiconductor Dimmers for Incandescent Lamps.
 - 5. NEMA WD 5: Specific Purpose Wiring Devices.
 - 6. UL 943: Standard for Ground Fault Circuit Interrupters.

- B. Acceptable Manufacturers:
 - 1. Hubbell.
 - 2. Pass and Seymour.
 - 3. General Electric.
 - 4. TayMac.
 - 5. Lutron.
 - 6. Leviton.

- C. Wall Switches:
 - 1. Provide wall switches for lighting circuits and motor loads under 1/2 HP conforming to NEMA WD; FS W-S-896; AC-general use snap switch with toggle handle, rated 20 amperes and 120-277VAC.
 - 2. Provide switch with gray handle.

3. For exterior applications, provide cast box and weatherproof actuating lever toggle switch cover.
- D. Receptacles:
1. Provide convenience and straight-blade receptacles conforming to NEMA WD 1, locking blade receptacles conforming to NEMA WD 5, and convenience receptacle configuration conforming to NEMA WD 1; Type 5-20, gray plastic face.
 2. Provide specific-use receptacle configuration conforming to NEMA WD 1 type as indicated on the drawings, and with a brown plastic face.
 3. Provide GFCI duplex convenience receptacles with integral ground fault current interrupters and gray plastic face.
- E. Wall Plates:
1. Provide type 304 stainless steel oversized (jumbo) interior wall plates.
 2. Provide continuous-use rated exterior device cover. Provide cover constructed entirely of UV stabilized high impact polycarbonate material with gasket, stainless steel mounting screws and UL listed for wet location continuous-use. Provide cover equal to TayMac Specification Grade series.
 3. Design plates to fit the device or devices on which they are used.

2.9 LIGHTING

- A. Applicable standards:
1. FS W-F-414: Fixture, Lighting.
 2. ANSI C82.5: Specification for HID Ballasts.
 3. ANSI C82.1: Specification for Fluorescent Lamp Ballasts.
- B. Provide light fixtures as scheduled on Drawings.

2.10 DISCONNECT/SAFETY SWITCHES

- A. Applicable standards:
1. ANSI/UL 198C: High intensity capacity fuses; current limiting types.
 2. ANSI/UL 198E: Class R fuses.
 3. FS W-F-870: Fuse holders (for plug and enclosed cartridge fuses).
 4. FS W-S-865: Switch, box (enclosed), surface-mounted.
 5. NEMA KS 1: Enclosed switches.
- B. Acceptable manufacturers – disconnect/safety switches:
1. ABB.
 2. Schneider Electric.
 3. Eaton.

C. Disconnect/Safety Switches:

1. Fusible (safety) switch assemblies: NEMA KS 1; type HD, quick-make, quick-break, load interrupter enclosed knife switch with externally operable handle interlocked to prevent opening front cover with switch in ON position.
 - a. Provide override screw to permit opening front cover with switch in ON position.
 - b. Provide the handle lockable in OFF position.
 - c. Provide fuse clips designed to accommodate Class R fuses.
 - d. Provide enclosure types as indicated on Drawings
2. Non-fusible (disconnect) switch assemblies: NEMA KS 1; type HD; quick-make, quick-break, load interrupter enclosed knife switch with externally operable handle interlocked to prevent opening front cover with switch in ON position.
 - a. Provide override screw to permit opening front cover with switch in ON position.
 - b. Provide the handle lockable in OFF position.
 - c. Provide enclosure types as indicated on Drawings.

D. Fuses:

1. Fuses 600 Amperes and Less: Current limiting type.
2. Fuse Interrupting Rating: 200,000 RMS symmetrical amperes.

E. Acceptable manufacturers - fuses:

1. Gould-Shawmut.
2. Bussman.

F. XXX/Y/ZZ/fAAA: Indicates device or equipment shall be supplied with a disconnect/safety switch. "XXX" indicates frame size; "Y" indicates number of poles; "ZZ" indicates enclosure NEMA rating ("3R" = NEMA 3R, "4X" = NEMA 4X); and "fAAA" indicates fuse size ("FPM" = fuse per manufacturer requirements), no text indicates non-fused disconnect switch.

2.11 ENCLOSED CIRCUIT BREAKERS

A. Applicable standards:

1. FS W-C-375: Circuit Breakers, Molded Case, Branch Circuit and Service.
2. NEMA AB 1-93: Molded Case Circuit Breakers and Molded Case Switches.
3. UL-489: Molded Case Circuit Breakers and Circuit Breaker Enclosures.
4. UL-50: Cabinets and Boxes.
5. NEMA-250: Enclosures for Electrical Equipment.

B. Acceptable manufacturers:

1. ABB.
2. Schneider Electric.

3. Eaton.
- C. Enclosed Circuit Breakers:
1. Enclosed Molded-Case Circuit Breaker: NEMA AB 1, lockable handle. Handle lockable in OFF position. Provide enclosures type as indicated on Drawings
 2. Provide frame size, trip rating, number of poles, and auxiliary devices as indicated, interrupting capacity rating to meet available fault current, with appropriate listing when utilized for switching fluorescent lighting, heating, air-conditioning and refrigeration equipment.
 3. Provide shunt-trip where indicated, 120V, 60Hz.
 4. Provide interchangeable trip units, on circuit breakers 200 amps and larger, with trip units interchangeable within frame size.

2.12 PANELBOARDS

- A. Applicable standards:
1. FS W-C-375: Circuit Breakers, Molded Case, Branch Circuit and Service.
 2. FS W-F-870: Fuse Holders (for Plug and Enclosed Fuses).
 3. FS W-F-115: Power Distribution Panel.
 4. FS W-S-865: Enclosed Knife Switch.
 5. NEMA AB 1: Molded Case Circuit Breakers.
 6. NEMA PB 1: Panelboards.
 7. NEMA PB 1.1: Instructions for Safe Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less.
 8. NEMA PB 1.2: Application Guide for Ground-fault Protective Devices for Equipment.
 9. UL 67: Panelboards.
- B. Acceptable manufacturers:
1. ABB.
 2. Schneider Electric.
 3. Eaton.
- C. Power Distribution panelboards:
1. Panelboards: NEMA PB 1; circuit breaker type.
 2. Enclosure: NEMA PB 1, Type 12, unless shown otherwise on the Drawings.
 3. Panelboard mounting as shown on the Drawings.
 4. Provide cabinet front with concealed trim clamps, and hinged door with flush lock. Finish in manufacturer's standard gray enamel.
 5. Provide panelboards with tin plated, copper bus, ratings as scheduled.
 6. Provide copper ground bus in all panelboards. Minimum integrated short circuit rating: As shown in panel schedules.
 7. Molded case circuit breakers: NEMA AB 1; provide bolt-in-type circuit breakers with integral thermal and instantaneous magnetic trip in each pole.

8. Provide circuit breakers UL listed as type HACR for air conditioning equipment branch circuits.
 9. Molded case circuit breakers with current limiters: AB 1; provide circuit breakers with replaceable current limiting elements, in addition to integral thermal and instantaneous magnetic trip in each pole.
 10. Provide panelboards with typed directory as shown on panel schedules.
 11. Provide panelboards keyed alike.
- D. Branch circuit panelboards:
1. Lighting and appliance branch circuit panelboards: NEMA PB 1; circuit breaker type.
 2. Enclosure: NEMA PB 1; Type 12, unless shown otherwise on the Drawings
 3. Cabinet size: 5-3/4" deep; 20" wide.
 4. Panelboard mounting as shown on the Drawings.
 5. Provide cabinet front with concealed trim clamps, concealed hinge and flush lock all keyed alike. Finish in manufacturer's standard gray enamel.
 6. Provide panelboards with tin plated, copper bus, ratings as scheduled on Drawings.
 7. Provide copper ground bus in all panelboards.
 8. Minimum integrated short circuit rating: As shown in panel schedules.
 9. Molded case circuit breakers: NEMA AB 1; bolt-on type thermal magnetic trip circuit breakers, with common trip handle for all poles.
 - a. Provide circuit breakers UL listed as Type SWD for lighting circuits.
 10. Provide UL Class A ground fault interrupter circuit breakers where scheduled on Drawings.
 11. Provide panelboards with typed directories as shown on panel schedules.
 12. Provide panelboards keyed alike.

2.13 MOTOR CONTROLLERS

- A. Motor starter designations:
1. FVNR: Full Voltage Non-reversing (default type if none shown).
 2. FVR: Full Voltage Reversing.
 3. RVSS: Reduced Voltage Solid State.
 4. RVAT: Reduced Voltage Auto Transformer.
- B. Provide each combination motor starter with magnetic circuit protection (MCP), rated for 65,000 AIC symmetrical at 480V.
- C. Provide FVNR, FVR, RVAT, and RVSS motor starters as 600V, NEMA-type, electrically operated, electrically held, three-pole assemblies with arc extinguishing characteristics and silver-to-silver renewable contacts.
- D. Make provisions for a total of eight (8) NO or NC auxiliary contacts.
- E. Provide each starter with a time delay relay adjustable from 0 to 3 minutes, 6-digit running time meter, a fused control power transformer, two (2) indicating lights (one red for running, green for

- ready), HOA selector switch, and two (2) NO contacts, unless otherwise scheduled on the drawings.
- F. Provide device panel with space to accommodate six (6) oil-tight pilot-control devices or indicating ammeters, voltmeters, or elapsed time meters.
 - G. Provide ambient compensated type overload protection for starters in NEMA 3R or 4X outdoor enclosures.
 - H. Provide thermal bimetallic ambient compensated type overload relay assembly, unless indicated otherwise.
 - I. Provide the overload relay with built-in push-to-test button, electrically isolated NO-NC contacts and single-phase sensitivity.
 - J. RVSS
 - 1. Equip each RVSS combination motor starter with built-in electronic overload protection, phase loss/phase imbalance, phase reversal sensing and DeviceNet module.
 - 2. Provide adequate inputs/outputs for start/stop control and run indication.
 - 3. Provide paralleling run bypass contactor that energizes when the motor reaches 90% of full speed and closes/opens under one (1) times the motor current contacts.
 - K. For motor controllers housed in separate enclosure, provide 30mm heavy-duty pilot lights, push buttons, switches, etc.
 - L. Provide NEMA rated, FVNR, combination motor starters for motors 25HP and less and NEMA rated, reduced voltage, combination motor starters, type as shown, for motors greater than 25HP.
 - M. Provide RVSS starters with DeviceNet module with the following control and status capability:
 - 1. ON-OFF reset control functions.
 - 2. Status (ON, OFF, TRIPPED, NO RESPONSE).
 - 3. Current phases A, B, C (I)
 - 4. Voltage A-B, B-C, C-A, L-N (V)
 - 5. Total harmonic distortion voltage (THDv)
 - 6. Total harmonic distortion current (THDi)
 - 7. Power factor (%)
 - 8. Maximum demand (kW)
 - 9. Maximum demand (kVA)
 - 10. Kilowatt hour usage (kWH)
 - 11. Percent phase unbalance.
 - 12. Control voltage.
 - 13. Overload protection settings.
 - 14. Trip current magnitude.
 - 15. Average motor current.
 - 16. Hand/Manual/Automatic.
 - 17. Cause of trip indication.
 - a. Phase loss.

- b. Phase unbalance.
- c. Ground fault.
- d. Thermal trip.

2.14 AUTOMATIC TRANSFER SWITCH (CONTACTOR TYPE-FURNISHED BY GENERATOR SUPPLIER)

- A. Applicable standards:
 - 1. UL 1008: Standard for Automatic Transfer Switches.
 - 2. NFPA 70: National Electrical Code.
 - 3. NFPA 99: Essential Electrical Systems for Health Care Facilities.
 - 4. NFPA 110: Emergency and Standby Power Systems.
 - 5. IEEE 446: IEEE Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications.
 - 6. NEMA ICS10-1993: AC Automatic Transfer Switches.
- B. Acceptable manufacturers:
 - 1. American Switch Company (ASCO).
 - 2. Caterpillar.
 - 3. Cummins.
- C. The following specifications are based on the ACSO 300 series power transfer switch and should be considered as a minimum for features and quality.
- D. Provide a stand-alone automatic transfer switch rated for 277/480 volt, 3-phase, 4-wire, wye, 60 Hz. Provide unit enclosures as shown on drawings with NEMA 1 as a minimum.
- E. Provide switch as true double throw, mechanically held, electrically operated, utilizing a reliable field proven, single-solenoid operator with contacts easily accessible for inspection and preventive maintenance.
- F. Provide 3-pole switch with solid neutral as shown on drawings.
- G. Provide amperage and voltage ratings as shown on drawings.
- H. Provide the following features:
 - 1. Microprocessor Controls.
 - 2. Optically isolated RS-485 Serial Communication Interface.
 - 3. In-phase Monitor.
 - 4. Selective Load Disconnect.
 - 5. Engine Exerciser.
 - 6. Solid Neutral.
 - 7. Switch Position Lights.
 - 8. Source Availability Lights.
 - 9. Test Switch.
 - 10. Time Delay Bypass Switch.

11. One (1) NO and one (1) NC Contacts Rated 10 amps 250VAC.
12. 60 or 50 Hz Selectable.
13. 3 phase or 1 phase Selectable.
14. Two (2) NO and two (2) NC Auxiliary Contacts.
15. Manual Transfer Option.
16. Strip Heater with Thermostat.
17. Serial Communication Board.
18. Deluxe Exerciser.
19. Time Delay Adjustments:
 - a. Override Momentary Normal Outage - 1-3 Seconds.
 - b. Transfer to Emergency - 0-5 Minutes.
 - c. Override Momentary Emergency Outage - 4 Seconds.
 - d. Retransfer to Normal - 1 Second – 30 Minutes.
 - e. Unloaded Running Time Cool Down - 5 Minutes.

20. Voltage and Frequency Settings:

- a. Normal Source Voltage:
 - 1) PU - 90%-95%
 - 2) DO - 70%-85%
- b. Emergency Source Voltage:
 - 1) PU - 90%
 - 2) DO - 75%
- c. Emergency Source Frequency:
 - 1) PU - 95%
 - 2) DO - 85%

- I. Switch manufacturer shall maintain a full-time service center located within 150 miles of job site location for warranty and non-warranty repair.

2.15 ENERGY EFFICIENT DRY TYPE TRANSFORMERS (600V MAX.)

- A. Applicable standards:
 1. NFPA 70: National Electrical Code.
 2. NEMA ST20: Dry Type Transformers for General Applications.
 3. UL 1561: Standard for Safety for Dry-Type General Purpose and Power Transformers.
 4. UL 506: Specialty Transformers.
 5. NEMA TP1: Guide for Determining Energy Efficiency for Distribution Transformers.
 6. NEMA TP2: Standard Test Method for Measuring the Energy Consumption of Distribution Transformers.
 7. ANSI C89: Specialty Transformers.

B. Acceptable manufacturers:

1. ABB.
2. Schneider Electric.
3. Eaton.

C. Refer to Drawings for actual layout and location of equipment and components; current ratings of devices, bus bars, and components; voltage ratings of devices, components and assemblies; and other required details.

1. Provide dry-type general-purpose transformers rated as indicated in drawings.
2. Provide UL listed transformers 750kVA and smaller.
3. All insulating materials are to exceed NEMA ST20 standards and be rated for 220°C UL component recognized insulation system.
4. Provide transformers 15kVA and larger with 150°C temperature rise above 40°C ambient.
5. Provide transformers 25kVA and larger with a minimum of 4 - 2.5% full capacity primary taps. Verify exact voltages and taps with plans or the transformer schedule.
6. Locate dry type transformers in well-ventilated areas, free from excess humidity, dust and dirt and away from hazardous materials. Ambient temperature of area will be between - 30°C and +40°C. Protect indoor locations to prevent moisture from entering enclosure.
7. Provide weather shields, wall mounting brackets and ceiling mounted brackets as required for installation location.
8. Provide aluminum coils.

D. Transformer Construction

1. Provide transformer coils of the continuous wound construction and impregnated with non-hygroscopic, thermosetting varnish.
2. All cores to be constructed with low hysteresis and eddy current losses.
3. Magnetic flux densities are to be kept well below the saturation point to prevent core overheating.
4. For transformers greater than 500kVA, clamp cores utilizing insulated bolts through the core laminations to ensure proper pressure throughout the length of the core. Bolt the completed core and coil to the base of the enclosure. Isolate by means of rubber vibration-absorbing mounts.
5. Provide no metal-to-metal contact between the core and coil and the enclosure except for a flexible safety ground strap. Sound isolation systems requiring the complete removal of all fastening devices will not be acceptable.
6. Visibly ground the core of the transformer to the enclosure by means of a flexible grounding conductor sized in accordance with applicable UL and NEC standards.
7. Provide ventilated transformer enclosures fabricated of heavy gauge, sheet steel construction.
8. Finish the entire enclosure utilizing a continuous process consisting of degreasing, cleaning and phosphatizing, followed by electrostatic deposition of polymer polyester powder coating and baking cycle to provide uniform coating of all edges and surfaces.
9. Provide UL recognized coating for outdoor use.
10. Provide ANSI 49 coating color.

- E. Provide low loss type transformers with minimum efficiencies per NEMA TP1 when operated at 35% of full load capacity. Test efficiency in accordance with NEMA TP2.

Single Phase		Three Phase	
kVA	Efficiency	kVA	Efficiency
15	97.7%	15	97.0%
25	98.0%	30	97.5%
37.5	98.2%	45	97.7%
50	98.3%	75	98.0%
75	98.5%	112.5	98.2%
100	98.6%	150	98.3%
167	98.7%	225	98.5%
250	98.8%	300	98.6%
333	98.9%	500	98.7%
		750	98.8%

- F. Provide transformers with sound levels warranted by the manufacturer and not to exceed the following:

kVA	Sound Level	kVA	Sound Level
15-50	45dB	501-700	62dB
51-150	50dB	701-1,000	64dB
151-300	55dB	1,001-1,500	65dB
301-500	55dB	1,501-2,000	66dB

- G. Load Taps:

1. Provide three phase transformers with the following high voltage load tap arrangements unless noted otherwise in plans:
 - a. Up through 15 KVA – no taps
 - b. 25 through 300kVA – 6-2.5% taps, 2-above and 4-below nominal.
 - c. 500 through 750kVA – 4-3.5% taps, 2-above and 2-below nominal.
 - d. Over 750kVA – 2-5% taps, 1-above and 1-below nominal.
2. Provide single phase transformers with the following high voltage load tap arrangements unless noted otherwise in plans:
 - a. Up through 15 KVA – no taps
 - b. 25 through 250kVA – 6-2.5% taps, 2-above and 4- below nominal.

- H. Testing

1. Provide transformers with the following production tests:
 - a. Applied Potential.
 - b. Induced Potential.
 - c. No Load Losses.
 - d. Voltage Ratio.
 - e. Polarity and Phase Rotation.
 - f. Continuity.
 - g. Sound Level.
 - h. Basic Impulse Insulation Level.

2. Provide the following manufacturer performed tests on units identical to the design type being supplied to this specification. Provide test data sheets to prove performance of these tests, when requested.
 - a. Sound Levels.
 - b. Temperature Rise Tests.
 - c. Full-Load Losses.
 - d. Regulation.
 - e. Impedance.

2.16 CONCRETE SUPPORT FOUNDATIONS

- A. Install each freestanding unit of electrical equipment on a 4" thick, 3000 PSI wire mesh reinforced concrete pad or curb with 36" clear on front side and 12" clear on all remaining sides, unless otherwise noted on drawings. Provide $\frac{3}{4}$ " chamfer all sides.

2.17 MISCELLANEOUS MATERIALS

- A. Provide support framing, channel and associated accessories of aluminum or stainless steel conforming to the Drawings and to Sections 05990 and 06800 of these specifications, except in areas containing chemicals, whereby fiberglass reinforced plastic only shall be utilized.

- B. Provide and install equipment racks for panels as shown on the drawings and as described in the specifications, with the following as a minimum:
 1. Provide cross members consisting of two (2) horizontal pieces of pre-drilled 1-1/2" x 1-1/2" mounting channel, manufactured by Kindorff.
 2. Attach all struts with spring-loaded nuts and associated hardware provided by manufacturer of strut, and specifically designed for this purpose.
 3. Use 316 stainless steel stud nuts, manufactured by Kindorff.
 4. Support the mounting channel "cross bars" vertically by C-channels, 3" x 2" x 8'.
 5. Mount channels a maximum of 24" apart, center-to-center, quantity as required to accommodate equipment.

6. Provide a foundation buried 36" underground and secured with 3000 PSI concrete pad, sized as shown on plans with a minimum of 36" clear walking space in front of control panels and 12" on sides and rear of panel.
 7. Provide 3/4" chamfer on all concrete edges.
- C. Provide 316 stainless steel (bolts, nuts, washers, U-bolts, anchors, threaded rods, etc.) attachment hardware.

PART 3 – EXECUTION

3.1 SURFACE CONDITIONS

- A. Examine the areas and conditions under which work of this Section will be performed. Correct conditions detrimental to timely and proper completion of the Work. Do not proceed until unsatisfactory conditions are corrected.

3.2 PREPARATION

- A. Coordination:
1. Coordinate as necessary with other trades to assure proper and adequate provision in the work of those trades for interface with the work of this Section.
 2. Coordinate the installation of electrical items with the schedule for work of other trades to prevent unnecessary delays in the total Work.
 3. Where lighting fixtures and other electrical items are shown in conflict with locations of structural members and mechanical or other equipment, provide required supports and wiring to clear the encroachment.
- B. Data indicated on the Drawings and in these Specifications are as exact as could be secured, but their absolute accuracy is not warranted. The exact locations, distances, levels, and other conditions will be governed by actual construction and the Drawings and Specifications should be used only for guidance in such regard.
- C. Where outlets are not specifically located on the Drawings, locate as determined in the field by the Engineer. Where outlets are installed without such specific direction, relocate as directed by the Engineer and at no additional cost to the Owner.
- D. Verify all measurements at the building. No extra compensation will be allowed because of differences between work shown on the Drawings and actual measurements at the site of construction.
- E. Branch circuit wiring and arrangement of home runs have been designed for maximum economy consistent with adequate sizing for voltage drops and other considerations. Install the wiring with circuits arranged exactly as shown on the Drawings, except as otherwise approved in advance by the Engineer.

3.3 ELECTRICAL SERVICE

- A. Verify location of utility transformer pad and install per utility company specifications, providing all materials and labor required for a complete installation. Verify location of utility company secondary delivery point and report any discrepancies to the Engineer immediately.

3.4 TRENCHING AND BACKFILLING

- A. Perform trenching and backfilling associated with the work of this Section in strict accordance with the provisions of Section 02221 of these Specifications.

3.5 CONDUCTORS

- A. Install no conductor smaller than #12 AWG unless otherwise indicated.
- B. Provide copper conductors.
- C. Provide conductors as shown on the plans or as specified herein.
- D. Provide continuous wiring from outlet to outlet, identified by color and marked with size, grade and manufacturer.
- E. Provide continuous wiring without joints, through pull boxes.
- F. Provide minimum of #10 AWG conductors on branch circuits, which exceed 100' at 120 volts and 200' at 277 volts from panel to load center.
- G. Terminate #14 AWG stranded conductors where indicated for control, using insulated compression-type spade lugs.
- H. Terminate #12 AWG stranded conductors using insulated compression-type spade lugs.
- I. Install an equal number of conductors for each phase of a circuit in the same raceway or cable.
- J. The conductor lengths for parallel circuits must be made equal.
- K. Neatly train and lace all wiring inside boxes, equipment, and panel boards.
- L. Connect circuits sharing a common neutral to different phases regardless of the numbering.
- M. Provide phase, neutral, and ground conductors as required to accommodate metering installed. Any additional conductors required for meter to function properly shall be installed at the Contractor's expense.

3.6 COLOR CODE AND MARKERS

- A. Provide color-coding for #12 and #10 conductors as follows:

	277/480-Volt	120/208(240)-Volt
Phase "A"	Brown	Black
Phase "B"	Orange	Red
Phase "C"	Yellow	Blue
Neutral	White with Tracer	White
Ground	Green	Green

Mark all conductors #8 and larger and all feeders with plastic tape to match the above color-coding.

- B. Mark all 480-volt equipment with red laminated plastic nameplates having one-half inch (1/2") engraved lettering, reading "DANGER 480-VOLTS". Attach plate to equipment with stainless steel screws.
- C. Mark conductors within panelboards with self-sticking label bearing the number corresponding to the circuit number on the drawings. Connect these conductors to corresponding breaker in panel. Mark circuit numbers in outlet boxes only where color-coding is repeated by having two or more conductors of the same color.
- D. Mark equipment, panelboards, cabinets, control devices, starters, switches, etc. by means of black, white core laminated nameplates having 1/4" engraved lettering. Provide designations as indicated on the drawings. Attach plates to equipment with stainless steel screws.

3.7 SPLICES, CONNECTIONS, AND TERMINATIONS IN 600V. CONDUCTORS

- A. Provide final connections and/or terminations for all wiring indicated on the electrical drawings and in this division of the specifications. Equipment supplied under other divisions of the specifications that require electrical connections under this division shall be provided with Engineer approved wiring and termination diagrams.
- B. Splice only in accessible junction boxes.
- C. Thoroughly clean wires before installing lugs and connectors.
- D. Terminate spare conductors with electrical tape

3.8 RACEWAYS AND FITTINGS

- A. When PVC coated conduit systems are utilized, the raceway manufacturer prior to installation shall certify the Contractor. Submit certification to the Engineer in writing.
- B. When PVC coated conduit systems are utilized, provide inspection and certification of the complete raceway installation in writing by an authorized representative of the PVC coated materials supplier.

1. During the construction process, at regular intervals, and prior to any raceway being covered, the representative shall inspect the system until it is confirmed that it meets the manufacturer's intended requirements.
 2. Remove and reinstall any portion of the conduit installation that does not meet the intended installation methods at no additional cost to the Owner.
- C. Provide certification to insure that all PVC overlapping connections, conduit threading, thread coating, sealing, etc., has been performed in accordance with manufacturer's recommended procedures.
- D. Apply cold galvanizing compound to all field-cut threads prior to installation.
- E. In general, follow the raceway installation layout shown on the plans, however, this layout is diagrammatic only, and where changes are necessary due to structural conditions, other apparatus or other causes, make such changes without any additional cost to the Owner.
- F. Cut all conduits square using a saw or pipe cutter and de-burr cut ends.
- G. Install the conduit to the shoulder of fittings and couplings and fastened securely.
- H. Use conduit hubs, or sealing locknuts, for fastening conduit to cast boxes and for fastening conduit to sheet metal boxes in damp or wet locations.
- I. No more than the equivalent of three 90-degree bends may be installed between boxes.
- J. Use conduit bodies to make sharp changes in direction, as around beams.
- K. Use hydraulic one-shot conduit bender or factory elbows for bends in conduit larger than 2" size.
- L. Avoid Moisture traps where possible; where moisture traps are unavoidable, there must be a junction box with drain fitting provided at the conduit low point. Use suitable conduit caps to protect installed conduit against entrance of dirt, concrete, plaster, mortar, and moisture.
- M. Size all conduits for conductor type installed with $\frac{3}{4}$ " being the minimum size conduit allowed.
- N. Arrange conduit to maintain headroom and present a neat appearance.
- O. Route any exposed conduit and conduit above accessible ceilings parallel and perpendicular to walls and adjacent piping.
- P. Provide at all times a minimum of 6" clearance between conduit and piping and a 12" clearance between conduit and heat sources such as flues, steam pipes, and heating appliances.
- Q. Arrange all conduit supports to prevent distortion of alignment by conductor pulling operations.
- R. Fasten conduits above finished ceilings using straps, lay-in adjustable hangers, clevis hangers or bolted split stamped hangers.

1. Do not fasten conduit with wire or perforated pipe straps. All wire that was used for temporary conduit support during construction must be removed before conductors are pulled.
 2. All conduits must be supported at a maximum distance of 5' on centers.
- S. Group conduits in parallel runs where practical using a conduit rack.
- T. Make all underground conduit joints watertight by applying manufacturer's recommended thread compound. Thread compound must be conductive and be compatible with conduit and conductor-jacket material.
- U. Provide suitable pull string or #12 AWG insulated conductor in empty conduit, except sleeves and nipples.
- V. Maintain minimum 12" clearance between all conduits containing signal circuits and conduits containing power circuits.
- W. Install expansion-deflection joints where conduit crosses building expansion or seismic joints.
- X. Where conduit penetrates fire-rated walls and floors, the opening around the conduit must be sealed with UL listed foamed silicone elastomer compound.
- Y. Install exposed raceways either parallel or perpendicular to building walls.
- Z. Install raceways exposed on walls or free standing perpendicular to the floor.
- AA. Install exposed raceways on channel so as to provide a minimum spacing of ½" between raceway and the surface to which it is mounted.
- BB. Bends:
1. Where emerging from walls, ceilings, floor or concrete slabs, all conduit bends shall be made entirely within the structure (i.e.: the conduit shall emerge perpendicular to the surface and the bend shall be covered).
 2. Make all 90-degree conduit turns with factory-bent, rigid galvanized steel, long radius elbows.
 3. Utilize rigid galvanized steel, long radius elbows on all 90 degree conduit bends of 2" and larger.
- CC. Install no metal conduit in contact with the earth or concrete slab unless protected with PVC coating.
- DD. Provide necessary sleeves and chases where conduits pass through floors and walls, and provide other necessary openings and spaces, arranging for in proper time to prevent unnecessary cutting in connection with the Work.
- EE. Perform cutting and patching in accordance with the provisions for the original Work.

- FF. Refer to Section 02221 for minimum cover of underground conduits.
- GG. Seal all underground conduits at electrical equipment with duct seal.
- HH. Install sealing compound and fiber, per manufacturer's recommendation, in conduit sealing fittings. Tighten plugs per manufacturer's recommended torque.
- II. Install watertight conduit hubs on all conduits terminating in the top or sides of NEMA 3R, 4 or 4X enclosures. Use a sealing locknut having an integral gasket on conduits terminating in the bottom of such enclosures.
- JJ. Make motor lead connections and connections to other electrical equipment subject to vibration, or where indicated with flexible weatherproof type steel core conduit with wrapping and cover, factory assembled.
- KK. Conduit installations in hazardous locations as defined by Article 500 of the NEC must conform to the special requirements of Articles 501, 502, and 503 of the NEC.
- LL. Chapter 9 of the NEC shall apply unless larger raceways are specified.

3.9 CONDUIT SUPPORTS

- A. Seal all ends of non-metallic conduit support with manufacturer's recommended sealer.
- B. Provide UL listed vinyl end caps for all ends of strut-type metallic conduit supports.

3.10 GROUNDING AND BONDING

- A. Ground and bond the electrical system and motors in accordance with Article 250 of the NEC.
- B. Install electric bond around panels, cabinets, pull boxes, enclosures, etc., to incoming and outgoing sub-feed raceways by use of grounding type bushings.
- C. Install rod electrodes at locations indicated. Install additional rod electrodes as required to achieve specified resistance to ground.
- D. Provide grounding electrode conductor(s) and connect as shown on drawings.
- E. Bond together metal siding not attached to grounded structure; bond to ground.
- F. Provide separate, insulated, green equipment grounding conductor within each feeder and branch circuit raceway. Terminate each end on suitable lug, bus, or bushing.
- G. Provide grounding type bushings for conduits 1" or larger and bond to ground bar or lug of enclosure.
- H. Bond neutral and ground at service entrance only.

- I. Provide exothermic-type weld grounding connections that are buried or otherwise normally inaccessible, and excepting specifically those connections for which access is required for periodic testing.
- J. Make each grounding connection strictly in accordance with the manufacturer's written instructions. Failure to follow manufacturer's written instructions shall result in immediate rejection.
- K. Welds which have "puffed up" or which show convex surfaces, indicating improper cleaning, are not acceptable. Provide grounding connection devices compatible with the conductor(s) and/or rods being joined.
- L. Maximum acceptable resistance to earth ground is 25 Ohms. Provide testing of the service entrance system ground and verify the resistance to earth ground is within the specified requirements. If the existing service entrance ground does not meet the specified requirements, install additional rod electrodes as required to achieve specified resistance to ground.

3.11 TRANSIENT VOLTAGE SURGE PROTECTION

A. Factory Installed:

- 1. Install SPD on the load side of the main circuit breaker.
- 2. Provide circuit breaker disconnect for SPD as shown on plans.
- 3. Install SPD in accordance with manufacturer instructions.
- 4. Minimum lead length 6".
- 5. Provide a factory installed SPD where shown on the drawings.

B. Field Installed:

- 1. Connect SPD ground to service entrance grounding electrode conductor or to equipment grounding conductor if SPD located downstream of service entrance equipment. Confirm SPD installed per manufacturer's recommendation.
- 2. Install SPD on the load side of the main circuit breaker.
- 3. Install SPD in accordance with manufacturer instructions.
- 4. Maximum lead length 12".
- 5. Mount in NEMA 1 enclosure for interior locations and NEMA 4X enclosure for exterior locations.

3.12 METERING

A. Circuit Monitoring:

- 1. Flush mount in unit at a minimum height of 54".

3.13 OUTLET BOXES

- A. Do not install boxes back-to-back in walls. Install the boxes at a minimum of 6" apart except in acoustic-rated walls with a minimum separation of 12".
- B. Locate boxes in masonry walls such that only the cutting of the masonry unit corner is required. Coordinate masonry cutting such that neat openings for the boxes can be achieved.
- C. Provide knockout closures for unused openings.
- D. Support boxes independently of the conduits.
- E. Use multiple gang boxes where more than one device is mounted together; do not use sectional boxes. Provide barriers to separate wiring of different voltage systems.
- F. Install boxes in the walls without damaging wall insulation.
- G. Install outlets to locate luminaires as shown on plans. In inaccessible ceiling areas, position outlets and junction boxes within 6" of recessed luminaires, to be accessible through luminaire ceiling opening.
- H. Provide recessed outlet boxes in finished areas; secure boxes to interior wall and partition studs, accurately positioning to allow for surface finish thickness.
- I. Use stamped steel stud bridges for flush outlets in hollow stud wall, and adjustable steel channel fasteners for flush ceiling outlet boxes.
- J. Align wall mounted outlet boxes for switches, thermostats, and similar devices.
- K. Provide cast outlet boxes in locations (exposed to the weather) and indoor wet locations.
- L. Size all boxes in strict accordance with Article No. 370 of the NEC, except that no box will be less than the minimum specified.
- M. Check the location of all outlets to see that the outlets will clear any new or existing wall fixture, shelving, work tables, sinks, bulletin boards, etc. and the outlet will fit the area intended.
- N. Set floor boxes level and flush with finish flooring material. Use cast iron floor boxes for installations in slab on grade.
- O. Locate pull and junction boxes above accessible ceilings or in unfinished areas. Support pull and junction boxes independently of conduit.
- P. Install underground boxes as shown on drawings with top of box approximately 2" above finished grade. Install bottom of box over 12" of gravel to allow for adequate drainage.

3.14 CONVENIENCE OUTLETS AND SWITCHES

- A. Install wall switches at 48" above the floor level and 6" from edge of door jam on strike side, unless otherwise noted on Drawings

- B. Install wall switches with the OFF position down.
- C. Install convenience receptacles at 18" above the floor level or 6" above counter or backsplash.
- D. Install convenience receptacles with the grounding pole on top.
- E. Install all specific-use receptacles at heights shown on Contract Drawings.
- F. Install decorative plates on switch, receptacle, and blank outlets in finished areas using jumbo size plates for outlets installed in masonry walls.
- G. Install galvanized steel plates on outlet boxes and junction boxes in unfinished areas, above accessible ceilings, and on surface-mounted outlets.
- H. Install devices and wall plates flush and level.

3.15 LIGHTING FIXTURES

- A. Install lamps in luminaires and lamp holders.
- B. Support surface-mounted luminaires; provide auxiliary support, laid across top of ceiling TS, fasten to T using bolts, screws, rivets, or approved ceiling framing member clips.
- C. Install fluorescent luminaires larger than 2'x4' size independent of ceiling framing.
- D. Install recessed luminaires to permit removal from below. Install grid clips. Support luminaires independently with 12-gauge minimum, galvanized, soft-annealed, mild steel wire.
- E. Replace all non-operational lamps at completion of work.
- F. Touch up luminaire and pole finish at completion of work with manufacturer's color- respective touch up kit.
- G. Securely ground all lighting fixture housings.
- H. Align luminaires and clean lenses and diffusers at completion of work.
- I. Clean excess paint, dirt, and debris from installed luminaires.

3.16 POWER EQUIPMENT

- A. Provide power and control wiring for motor starters and safety switches as shown on the Drawings.
- B. Connections to miscellaneous building equipment:
 - 1. Wire to, and connect to, all items of building equipment not specifically described but to which electrical power is required.

2. Coordinate as necessary with other trades and suppliers to verify types, numbers, and locations of equipment.

3.17 MOUNTING OF CONTROL PANELS AND ELECTRICAL EQUIPMENT

- A. Install all equipment per the manufacturer's recommendations and the contract drawings.
- B. Install surface-mounted panelboards plumb, in conformance with NEMA PB 1.1.
- C. Install disconnect switches with centerline at 48" above finished floor, grade, etc. unless otherwise noted.
- D. Secure switchboard assemblies to foundation or floor channels.
- E. Secure disconnect switches to channel frames with spring-type fasteners and hardware intended for this specific use where wall mounted, unless otherwise indicated.
- F. Mount floor and wall mounted equipment utilizing Type 316 stainless steel anchors and fasteners of the size and number recommended by the manufacturer.
- G. Provide necessary hardware to secure the assembly in place.
- H. Provide 316 stainless steel fasteners for all other installation types.
- I. Inspect switchboards and panel boards for physical damage, proper alignment, anchorage, and grounding. Check proper installation and tightness of connections for circuit breakers, fusible switches, and fuses.
- J. Install and check all equipment in accordance with the manufacturer's recommendations.
- K. Ensure that equipment mounting pad locations are level to within 0.125 inches per three foot of distance in any direction. Notify Engineer immediately if any discrepancies are found in the field.
- L. Ensure that all equipment bus bars are torqued to the manufacturer's recommendations.
- M. Assemble all equipment shipping sections, remove all shipping braces and connect all shipping split mechanical and electrical connections.
- N. Provide filler plates for unused spaces in panelboards and switchboards.
- O. Provide typed circuit directory with protective plastic sleeve secured to inside of panel door for each branch circuit panelboard.
- P. Provide Micarta type labels located adjacent to each breaker operator, delineating equipment served for each circuit breaker in all switchboards.
- Q. Measure steady state load currents at each switchboard and panelboard feeder. Should the voltage difference measured at the equipment between any two phases exceed 20 percent, rearrange

circuits to balance the phase loads within 20 percent. Take care to maintain proper phasing for multi-wire branch circuits.

- R. Measure and recording Megger readings phase-to-phase, phase-to-ground, and neutral-to-ground (four wire systems only).

3.18 UNIT RESPONSIBILITY

- A. Switchboards, panelboards, relays, switches, starters, etc. furnished under this Section of the specifications shall be supplied by the same manufacturer so as to give unit responsibility and ease of maintenance.

3.19 HEATING, VENTILATING AND AIR CONDITIONING

- A. Provide all power wiring for the plumbing, heating, ventilating and A.C. systems as shown on the drawings and according to an approved wiring diagram furnished by the Mechanical Contractor.
- B. Control and interlock wiring shall be provided under other sections of these specifications, including conduit and outlet boxes required, except as specifically indicated on electrical drawings.
- C. Make all connections to equipment required for proper operation.
- D. Consult the mechanical drawings in detail for exact locations of all equipment.

3.20 TESTING AND INSPECTION

- A. Provide personnel and equipment, make required tests, and secure required approvals from the Engineer and governmental agencies having jurisdiction.
- B. Provide written notice to the Engineer adequately in advance of each of the following stages of construction:
 - 1. In the underground condition prior to placing concrete floor slab, when all associated electrical work is in place.
 - 2. When all rough-in is complete, but not covered.
 - 3. At completion of the work of this Section.
- C. When material and/or workmanship are found to not comply with the specified requirements, replace items within three days after receipt of notice at no additional cost to the Owner.
- D. Provide a qualified field serviceman, representing the manufacturer of each piece of major electrical equipment, to make proper and complete adjustments of all adjustable devices, load switches, etc. after final installation and completion of all field wiring. Verify and approve all connections prior to any initial or test operation of equipment. Submit confirmation in writing by the manufacturer's authorized representative of said services to the Engineer.

3.21 HAZARDOUS LOCATIONS

- A. Wiring and equipment in hazardous locations, as defined by the NEC, shall conform to the special requirements of the NEC, unless otherwise indicated or specified.

3.22 CLEANING AND PAINTING

- A. Collect and remove from the premises all debris, scraps and other waste material after completion of work.
- B. Tamp and level all trench work.
- C. Remove excess dirt and debris, when and as directed by the Engineer.
- D. Thoroughly clean all electrical equipment, lighting fixtures, exposed conduit, enclosures and boxes of all foreign materials and paint in accordance with Section 09900 of these Specifications unless noted or directed otherwise.
- E. Clean any exposed threaded area of raceway of cutting oil and paint with a cold galvanizing compound prior to final finish painting.

3.23 ELECTRIC EQUIPMENT BY OTHERS

- A. The equipment manufacturer shall furnish all motors for equipment.
- B. Verify voltage, dimensions, extent, type, etc. of this and all other such electrical equipment.
- C. Furnish and install all electrical supply and control equipment and material required to put all the items in proper operative condition.
- D. Refer to other sections of these specifications for verification of other equipment and devices requiring electrical connections, wiring and devices not included in this section.
- E. Refer to other drawings for details not indicated on the electrical drawings.
- F. Prior to connecting any piece of such equipment, check the nameplate data against the information shown on the drawings and call to the immediate attention of the Engineer any discrepancies discovered.

3.24 PROJECT COMPLETION

- A. Test all 600-Volt service entrance and feeder wiring using an instrument, which applies a voltage of approximately 500 volts DC to provide a direct reading of resistance.
- B. Perform test on ground system utilizing Fall-Of-Potential method. Meg grounding systems to measure ground resistance, and provide not more than 25 ohms resistance, adding ground rods as necessary to achieve that level.

- C. Tests shall be conducted by a NETA accredited test firm. Conduct all tests in presence of Engineer or his representative. Identify and properly record all readings. Submit readings to Engineer for acceptance.
- D. Measure voltages as directed by the Engineer and report to him these values.
- E. Provide entire system free from all shorts and grounds.
- F. Fully comply with local and national codes for equipment bonding and grounding.
- G. Test system in the presence of the Engineer and operate to his complete satisfaction in accordance with true intent of plans and specifications. Defray cost of all adjustments necessary to bring system up to standards set forth by Contract Documents at no additional cost.
- H. Thoroughly indoctrinate the Owner's operation and maintenance personnel in the contents of the operations and maintenance manual.
- I. On the first day the facility is in operation, for at least eight (8) hours at a time directed by the Engineer, provide a qualified foreman and crew to perform such electrical work as may be required by the Engineer.

3.25 MEASUREMENT AND PAYMENT

- A. No separate measurement or direct payment will be made for this work and all costs for same shall be included in the price bid for the work to which it pertains.

END OF SECTION

**SECTION 16680
VARIABLE FREQUENCY DRIVES**

PART 1 GENERAL

1.1 DESCRIPTION

A. Work included:

Provide and install new variable frequency drives (VFDs) in new enclosures as specified herein and as needed to provide complete and proper drive systems as described below:

Service	Horsepower	FLA
Georgetown Raw Water Pump 1	100	114
Georgetown Raw Water Pump 2	100	121
Liberty Steel Raw Water Pump 1	100	114
Liberty Steel Raw Water Pump 2	100	118

B. Related work:

1. Documents affecting work of this section include, but are not necessarily limited to, General Conditions, Supplementary Conditions and Sections in Division 1 of these specifications.
2. Section 13310 – Supervisory Control and Data Acquisition.
3. Section 16400 - Electrical.

1.2 QUALITY ASSURANCE

A. Manufacturer:

1. The referenced manufacturer of the variable frequency drives (VFDs) is Square D. Equivalent products by Eaton or Yaskawa are also approved manufacturers.
2. It is the intent of these specifications and drawings that the Contractor shall engage an approved and qualified manufacturer to provide the drive system as specified and indicated.
3. Manufacturer shall design and furnish a complete, integrated and functionally operating system, warranted to perform the intended functions as herein specified.
4. Provide or supply all instruments specified herein or required and provide all required and specified collateral services in connection with the system such as testing, calibration, start-up, operation and maintenance manuals.

C. Drives are to be manufactured in the United States.

D. Contractor:

1. Shall be fully and solely responsible for the work of the system supplier and solely responsible to the Owner for having supplied to the Owner the complete system.
2. To provide personal direction to the work, maintaining and supplying complete supervision over and coordination between all subcontractors employed by him.
3. To be responsible for defining the limits of his subcontractor's work.
 - a. Setting of drives and final connections shall be made by the Contractor and/or electrical subcontractor.

E. Technical services:

1. Provide the services of a factory trained service engineer, specifically trained on the type of control system specified herein and complying with Sections 01660 and 01600 at the following times:
 - a. Installation check and start-up: 4 days, 2 trips.
 - b. Operator training: 1 day, 1 trip.
 - c. Six months after start-up: 1 day, 1 trip.

1.3 SUBMITTALS

- A. Comply with pertinent provisions of Section 01340.
- B. Product data: Within 30 calendar days after the Contractor has received the Owner's Notice to Proceed, submit:
 1. Component manufacturing data sheet indicating pertinent data and identifying each component by item number and nomenclature as indicated on the drawings and in the specifications.
 2. Component drawing showing dimensions, mounting and external connection details.
 3. System wiring schematics, each on a single drawing with full description of operation. Component identification on the schematic shall be as indicated above.
 4. A system schematic of the hardware with the component manufacturing data sheets for each item, including all system peripherals.
- C. Provide Operation and Maintenance manuals complying with provisions of Section 01650.
 1. Operating instructions shall incorporate a functional description of the entire system, including the system schematics, which reflect "as-built" modifications.
 2. Special maintenance requirements particular to the system shall be clearly defined along with special calibration and test procedures.

1.4 COORDINATION OF WORK

- A. Coordinate work of this section with work of Sections listed in 1.1. B. above.

1.5 PRODUCT DELIVERY, HANDLING AND STORAGE

- A. Comply with pertinent provisions of Section 01640.
- B. Delivery of the VFDs shall be coordinated by the Contractor to meet the requirements of the Contract Documents.
 - 1. Each item of equipment to be tagged with identifying number shown on the shop drawings.
- C. Contractor's attention is directed to the fact that instruments and control system are delicate components which have been shop calibrated. Extreme care shall be taken in handling this control system to avoid internal and/or external damages.
- D. Damaged equipment will not be accepted.
- E. Store equipment not for immediate use inside a building, with enclosures under protective coverings, and fully protect from moisture, dust, extreme heat and vibration.

1.6 WARRANTY

- A. Comply with pertinent provisions of Section 01650.
- B. Manufacturer shall, during the warranty period of one year, furnish all service necessary to repair defective equipment or work, and no charges will be made for any service due to these reasons.
 - 1. For any service visit during this period, provide Owner and Engineer with written report stating the reason for drive system failure and recommendations to prevent recurrence.

1.7 SPARE PARTS

- A. Provide the following:
 - 1. Three (3) of each size fuse used in power service on primary power feed.
 - 2. Ten (10) of each type indicator lamp used.
 - 3. Ten (10) of each size and type of control relay used.
 - 4. Two (2) of each type of switch used on the panel face.
 - 5. One (1) spare panel ventilation filter for each enclosure.
 - 6. One (1) operator interface (HMI) unit.

- B. Package for long term storage.
- C. Clearly label each package with an item number and description.

PART 2 PRODUCTS

2.1 GENERAL

- A. Provide new and unused equipment and materials proven by previous use of similar products to be completely suitable for the service intended.
- B. Provide manufacturer's latest and proven design.
 - 1. Specifications and Drawings call attention to certain features, but do not purport to cover all details entering into the design of the instrumentation system.
 - 2. The completed system shall be compatible with the functions required and other equipment furnished by the Contractor.
- H. The VFDs and appurtenant equipment shall contain the fuses or switches required by the hardware manufacturer.
- I. Protect VFDs from voltage and/or current surges which may originate as a result of lightning or other external causes.
 - 1. Protective equipment to be provided by the equipment supplier and installed in accordance with his recommendations.
 - 2. Schematics of the equipment submitted for approval to the Engineer shall indicate how this protection will be provided and identify the items of equipment, which shall be used for this purpose.
- J. Provide "as-built" drawings containing all necessary information for proper maintenance and operation of the system.
 - 1. Interconnection information between system components and equipment found in other sections of these Specifications shall be complete with all necessary interconnection information.
 - 2. Notes that refer to equipment manufacturer's drawings for proper interconnection will not be acceptable.

2.2 VARIABLE FREQUENCY DRIVES

- A. Provide new drives capable of stopping, starting and controlling the motor speed.
- B. Provide drives with the following protective features: Ground fault, overvoltage, undervoltage, electronic motor overload, and over temperature.
- C. Attributes:

1. Input power of 480V ($\pm 10\%$), three phase.
 2. Input frequency of 60 Hz ($\pm 2\text{Hz}$).
 3. Power factor of 95% over the speed range.
 4. 96% or better efficiency at full speed.
- D. Output power shall have a sine coded Pulse Width Modulated Waveform.
- E. Output voltage shall be 0 to applied input voltage, maximum output voltage shall not exceed applied input voltage.
- F. Adjustable frequency from 0 to 400 Hz with a regulation of 0.01 Hz.
- G. RMS output current.
- H. All drive parameters shall be capable of being stored in a non-volatile memory (EEPROM). A door-mounted operator programming panel shall be provided to fully access all drive parameters and control features and be capable of being disabled to prevent unauthorized access.
- I. Design VFD with the following built-in protective features:
1. Built-In DC Bus Inductor.
 2. Built-In Common Mode Capacitors.
 3. Built-In Metal Oxide Varistors (MOVs).
- J. Provide capability to start/stop and control the speed of the motor from the PLC control panel.
- K. Provide a logic ride-thru minimum capability of 0.5-sec and a power ride-thru minimum capability of 15-msec for each VFD unit.
- L. Linear and programmable ACCEL/DECEL rates from 1 to 3600 seconds via the drive operator program panel.
- M. VFD shall be programmable for Sensorless Vector or Volts/Hertz mode.
- N. Provide programmable intermittent overload capability up to 150% or 200% of rated output current for up to one minute maximum, based on the schedules listed herein.
1. For normal-duty loads (ND), size each VFD based on the following normal-duty requirements:
 - a. VFD continuous output amps rating shall be higher than the Full Load Amps (FLA) of the motor that it is to control.
 - b. VFD 1-minute overload output amps rating shall be a minimum of 110% higher than the FLA of the motor that it is to control.

- c. VFD 3-second overload output amps rating shall be a minimum of 150% higher than the FLA of the motor that it is to control.
- 2. For heavy-duty loads (HD), size each VFD based on the following:
 - a. VFD continuous output amps rating shall be higher than the Full Load Amps (FLA) of the motor that it is to control.
 - b. VFD 1-minute overload output amps rating shall be a minimum of 150% higher than the FLA of the motor that it is to control.
 - c. VFD 3-second overload output amps rating shall be a minimum of 200% higher than the FLA of the motor that it is to control.
- O. At a minimum, the VFD overcurrent trip shall be 180% of Rated Output Current.
- P. Display drive faults on the operator's panel on the drive, and also capable of transmitting for display on an external SCADA HMI, with the last fault being stored in memory.
- Q. Install each VFD in a freestanding fan cooled NEMA 1 enclosure. The VFDs will be installed in an air-conditioned space. VFD enclosure shall have adequate space for all equipment identified herein and room for CTs and PTs for external submetering.
- R. Utilize the VFD Manufacturer's standard test procedure on each VFD unit.
 - 1. At a minimum, include a load test for each VFD unit.
 - 2. Include a copy of the test procedure in the submittal.
 - 3. Include a copy of each test report in the O & M manual.
- S. The speed variation range of each controller shall be from 1% to 100%.
- T. Each VFD unit shall have a programmable carrier frequency range from 2-10 kHz,selectable in increments of two (2) with the default setting of 4kHz.
- U. Features and Characteristics
 - 1. Each VFD unit shall be furnished with a Human Machine Interface (HMI) to provide controls and indication to accomplish maintenance and operational functions as specified herein and shown on the Drawings. The HMI shall be password protected after startup to prevent unauthorized personnel from making changes. The HMI shall at minimum provide indication of the following:
 - Input Voltage
 - Output Voltage
 - Output Current
 - Output Frequency
 - Output Speed from 0-100%
 - Alarm Read-out

2. Each VFD unit shall provide a 4-20 mADC output signal that is proportional to the drive output frequency for use as speed feedback/speed indication to external equipment.
3. Each VFD unit shall accept a 4-20 mADC speed input command signal to control the output frequency in the automatic and/or manual control modes as specified herein or indicated on the Drawings. The system shall accept the input increase/decrease command with a resolution that permits incremental changes in speed equal to or less than 0.1% of rated speed.
4. VFD units shall also accept a 0-10VDC input from a speed potentiometer mounted on the enclosure for manual speed control.

5. Input Voltage Loss Handling

The VFD unit shall shut down upon a loss of one or more input phases, a 3-phase complete input power loss, or a sustained input undervoltage event. A sustained input undervoltage event is defined as voltage that is less 75% of nominal, for more than 0.5 seconds.

6. Upon restoration of 3-phase power that is at an acceptable voltage level, the VFD unit shall automatically reset (after an adjustable time delay, 0-2 minutes) and be capable of being restarted and ramping up to speed when remotely commanded through the control system or locally commanded at any local controls. Personnel shall not be required to reset the VFD unit manually after a shutdown caused by any input voltage loss event.
7. Automatic reset of the VFD unit shall be achieved through programming/parameter setpoints, time delay relays, or a combination of both.

8. Each VFD unit shall have a multiple attempt restart feature.
9. Each VFD unit shall have an automatic current limit feature to control motor currents during startup and provide a "soft start" torque profile for the motor-load combination. The VFD unit shall also limit current due to motor winding or motor lead phase-to-phase short circuit or phase-to-ground short circuit. The current limit protection setting shall be field adjustable.
10. Each VFD unit shall be furnished with programmable electronic overload and torque limits.
11. Each VFD unit shall have an automatic trip feature which will remove the drive output from the motor and allow it to decelerate safely. This automatic system shall lock-out the VFD unit and indicate the fault only upon the following conditions:

Output voltage unbalance (trip threshold field set).

Loss of phase on output.

Motor overload.

Motor stator winding fault (phase-to-ground, phase-to-phase).

Unacceptable voltage variation.

High variable frequency drive equipment temperature.

VARIABLE FREQUENCY DRIVES

VFD failure as determined by the manufacturer.
Component failure.
Overcurrent.

12. Provide each VFD unit with transmitted and received radio interference protection. In addition, provide protection against starting a rotating motor, both directions (coasting to zero speed and backspin). In the event that a motor automatic restart feature (catch the motor "on-the-fly") is provided in the VFD unit, this feature shall be capable of being disabled.
 13. Each VFD unit shall include on-line diagnostics, with an automatic self-check feature that will detect a variable frequency drive failure.
 14. Diagnostics shall operate a visual alarm indicator on the HMI.
 15. Diagnostics shall provide an easily readable output that can be used to isolate a failure.
 16. Provide an event and diagnostic recorder to printout in narrative English of the specific fault(s) and the sequence in which the faults occurred. An indication of the "First Out" failure is a minimum for fault sequence detection.
 17. Provide normally open and/or normally closed dry contacts as indicated on the Drawings for VFD failure conditions.
 18. Each VFD unit shall communicate the following parameters to the control system via Modbus TCP protocol. Provide any necessary hardware gateways to provide this communication capability. The following parameters, at a minimum, shall be communicated:
 - Motor current (all phases)
 - Motor voltage (all phases)
 - Motor KW
 - V. The VFDs shall include an RJ45 port for Modbus TCP to interface with PLC panel as described in I/O list shown on the drawings.
 - W. Each VFD shall include the following pilot lights on the enclosure: RVSS MODE, VFD MODE, VFD ON, VFD FAULT, RVSS ON, RVSS FAULT, HIGH MOTOR TEMP.
 - X. Each VFD shall include the following operators on the enclosure: VFD-OFF-BYPASS, HAND-OFF-AUTO selector switches and a manual speed potentiometer.
 - Y. The control power transformer shall be oversized for the motor space heater.
- 2.3 HARMONIC CORRECTION
- A. Harmonic correction devices for each VFD shall consist of a passive filter as described below or an active front end.
 - B. Input Line Reactors-6-pulse VFD units shall be provided with input line reactor and/or integral DC link reactor. Total reactor impedance shall be a minimum of 3% and shall not exceed 5%.

C. Passive Filters

1. Where indicated on the Drawings or where additional harmonic correction is required, 6-pulse VFD units shall be provided with a passive harmonic filter in addition to the integral DC link reactor specified above (if present.)
2. Passive harmonic filters shall be sized to attenuate harmonics resulting from operation of the VFD-driven motor load to no more than 5% THID when operating at full load, and no more than 8% THID when operating at 30% of full load. The filter shall be equipped with power contactors configured to remove the capacitors from the circuit when the VFD-driven loads are not in operation. The harmonic filters shall be as manufactured by TCI, MTE Corporation, Mirus International, or Engineer approved equal.
3. Passive filters shall be integrated into the VFD enclosure unless accepted in writing by the Engineer or shown as separately mounted from the VFD on the Drawings.

C. DV/DT Filters

1. Provide DV/DT filters on the output of each drive.

2.4 BYPASS STARTER

- A. Bypass Operation: Safely transfers motor between power converter output and bypass circuit manually with motor completely disconnected from power converter.
- B. Bypass Controller: Three-contactor-style bypass allows motor operation via the power converter or the bypass controller arranged to isolate the power converter input and output and permit safe testing of the power converter, both energized and de-energized, while motor is operating in bypass mode.
 1. Bypass Contactor: Load-break, NEMA-rated contactor.
 2. Input and Output Isolating Contactors: Non-load-break, NEMA rated contactors.
 3. Isolating Switch: Non-load-break switch arranged to isolate power converter and permit safe troubleshooting and testing of the power converter, both energized and de-energized, while motor is operating in bypass mode; pad-lockable, door-mounted handle mechanism.
- C. Bypass Contactor Configuration: Reduced-voltage soft starter type.
 1. Contactor Coils: Pressure-encapsulated type.
 - a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.
 - b. Power Contacts: Totally enclosed, double break, and silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.

2. Control Circuits: 24-V dc; obtained from integral power supply of sufficient capacity to operate all integral devices and remotely located pilot, indicating, and control devices.
3. Overload Relays: NEMA ICS 2.
 - a. Solid-State Overload Relays:
 - 1) Switch or dial selectable for motor-running overload protection.
 - 2) Sensors in each phase.
 - 3) Class 10/20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
 - 4) Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
 - 5) Analog communication module.
 - b. NC isolated overload alarm contact.
 - c. External overload, reset push button.

PART 3 - EXECUTION

3.1 LOCATION

- A. Locate all equipment, wiring, etc., as indicated.
- B. Securely anchor all equipment to floors or walls.

3.2 FIELD WIRING

- A. All power, signal, and control wiring and conduit required for the VFD system to be furnished, installed, and terminated by the Contractor.
- B. This wiring is defined as:
 1. All single phase 120 VAC or less.
 2. Direct current.
 3. Audio cable.
 4. Special shielded signal cable.
 5. Any wiring for control, report back or signal purposes between panels, terminal units and all field mounted devices.
- C. Wiring materials, methods of installation, etc. shall conform to Section 16400.

3.3 STARTUP

- A. Each VFD shall be started up and tested on utility power and generator power,
- B. All final VFD and soft starter settings shall be documented and submitted with Operation and Maintenance Manuals.

3.4 SUBSTANTIAL COMPLETION

- A. Acceptance of drive systems as substantially complete will be made only when:
 - 1. All pertinent requirements of Sections in Division I are met.
 - 2. All mechanical systems being served by the drives become fully operational to the extent that the said drives can be fully utilized and are capable of demonstrating performance during conditions, which simulate the Engineer's design parameters for the respective systems.

3.4 MEASUREMENT AND PAYMENT

- A. No separate measurement or direct payment will be made for the work under this Section and all costs of same shall be included in the lump sum price bid for the project.

END OF SECTION