# TECHNICAL SPECIFICATIONS


SECTION 01010

SUMMARY OF WORK

PART 1 -- GENERAL

1.01 THE REQUIREMENT

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 construction of the Mount Holly Commerce Park Improvements Phase 1. 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 principal features of the Work to be performed under these Contracts includes:

Work may include, but is not limited to, the Civil, Structural, Mechanical and Electrical Improvements. Offerors must be able to provide all supervision, manpower, materials, equipment and supplies necessary to complete any scope of work outlined. The services to be provided shall include but not be limited to the following:

1. Construction of a new Pump Station 094 including three (3) new (2 duty and 1 stand-by) one hundred and forty horsepower pumps (Reduced Voltage Soft Start) and one (1) thirty-four horsepower pump (Variable Frequency Drive).

2. Demolition of existing pump station.

3. Construction of a new receiving manhole and modifications to existing gravity sewer system including new piping and manholes.

4. Construction of approximately 12,300 linear feet of 24-inch forcemain and miscellaneous piping and valves.

5. Construction of a new asphalt access drive.

6. Construction and installation of equipment and concrete pads, (1) 350kW diesel generator system with fuel tank in a prefabricated enclosure, electrical switchgear, motor control centers, instrumentation and control hardware and software, power and control conduit and wiring.

7. Site grading and asphalt paving.

8. Installation and operation of temporary by-pass pumping.

C. The foregoing description(s) shall not be construed as a complete description of all work required.

1.02 CONTRACT DOCUMENTS

A. The Work to be done is shown on the set of Drawings entitled Mount Holly Commerce Park Improvements Phase I project and Dated February 2020. The numbers and titles of all Drawings appear on the index sheet of the Drawings, Drawing G01. All drawings so enumerated shall be considered an integral part of the Contract Documents as defined herein.

B. Certain Document Sections refer to Divisions of the Contract Specifications. Sections are each individually numbered portions of the Specifications (numerically) such as 08110, 13182, 15206, etc. The term Division is used as a convenience term meaning all Sections within a numerical grouping. Division 16 would thus include Sections 16000 through 16902.

C. 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.

1.03 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.

1.04 CONSTRUCTION PERMITS, EASEMENTS AND ENCROACHMENTS

A. The Owner shall obtain or cause to be obtained a right-of-way encroachment permit from SCDOT. The Contractor shall verify that these permits have been obtained and shall comply with the conditions set forth in each agreement.

B. 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.

C. 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.

D. The Contractor shall provide any required Performance and Indemnity Bond(s) and any additional specific insurance coverage required of the Owner by the Encroachment Agreement(s) in accordance with the Encroachment Agreement(s) between the Owner and the South Carolina Department of Transportation. The Contractor shall fully comply with all of the requirements of the Owner included in the Encroachment Agreement(s).

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1.05 ADDITIONAL ENGINEERING SERVICES

A. In the event that the Engineer is required to provide additional engineering services as a result of substitution of materials or equipment which are not "or equal" by the Contractor, or changes by the Contractor in dimension, weight, power requirements, etc., of the equipment and accessories furnished, or if the Engineer is required to examine and evaluate any changes proposed by the Contractor for the convenience of the Contractor, then the Engineer's charges in connection with such additional services shall be charged to the Contractor by the Owner.

B. Structural design shown on the Contract Drawings is based upon typical weights for major items of equipment as indicated on the Contract Drawings and specified. If the equipment furnished exceeds the weights of said equipment, the Contractor shall assume the responsibility for all costs of redesign and for any construction changes required to accommodate the equipment furnished, including the Engineer's expenses in connection therewith.

C. In the event that the Engineer is required to provide additional engineering services as a result of Contractor's errors, omissions, or failure to conform to the requirements of the Contract Documents, or if the Engineer is required to examine and evaluate any changes proposed by the Contractor solely for the convenience of the Contractor, then the Engineer's charges in connection with such additional services shall be charged to the Contractor by the Owner.

1.06 ADDITIONAL OWNER'S EXPENSES

A. In the event the Work of this Contract is not completed within the time set forth in the Contract or within the time to which such completion may have been extended in accordance with the Contract Documents, the additional engineering or inspection charges incurred by the Owner may be charged to the Contractor and deducted from the monies due him. Extra work or supplemental Contract work added to the original Contract, as well as extenuating circumstances beyond the control of the Contractor, will be given due

consideration by the Owner before assessing engineering and inspection charges against the Contractor.

B. Unless otherwise specifically permitted, the normal time of work under this Contract is limited to 8 hours per day, Monday through Friday. Work beyond these hours will result in additional expense to the Owner. Any expenses and/or damages, including the cost of the Engineer's on site personnel, arising from the Contractor's operations beyond the hours and days specified above shall be borne by the Contractor.

C. Charges assessed to the Contractor for additional engineering and inspection costs will be determined based on actual hours charged to the job by the Engineer. Daily rates will depend on the number and classifications of employees involved, but in no case shall such charges exceed $600 per day for field personnel and $600 per day for engineering personnel, based on an eight hour workday.

D. Charges for additional Owner's expenses shall be in addition to any liquidated damages assessed in accordance with the Contract.

1.07 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 6:00 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.

1. The Owner shall deduct the cost of additional engineering costs from monies due 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.

C. Unless otherwise specifically permitted, all work that would be subject to damage shall be stopped during inclement, stormy or freezing weather. Only such work as will not suffer injury to workmanship or materials will be permitted. Contractor shall carefully protect his work against damage or injury from the weather, and when work is permitted during freezing weather, he shall provide and maintain approved facilities for heating the materials and for protecting the finished work.

1.08 SUBSURFACE DATA

A. Subsurface data are offered in good faith solely for placing the Bidder in receipt of all information available to the Owner and Engineer and in no event is to be considered as part of the Contract Documents.

B. The Bidder must interpret such subsurface data according to his own judgment and acknowledge that he is not relying upon the same as accurately describing the subsurface conditions, which may be found to exist.

1. The test boring logs present factual information of the subsurface conditions at the specific test boring location only. The Bidder should not consider, or conclude, that the subsurface conditions will be consistent between test boring locations.

C. The Bidder further acknowledges that he assumes all risks contingent upon the nature of the sub-surface conditions to be actually encountered by him in performing the work covered by the Contract, even though such actual conditions may result in the Bidder performing more or less work than he originally anticipated.

D. The Bidder is further advised that the Owner has made sub-surface investigations and a report has been prepared, in connection with this project for the Engineer, a copy of which is appended to the rear of these specifications.

E. In making this data available, the Owner makes no guarantee, either expressed or implied, as to their accuracy or to the accuracy of any interpretation thereof.

1.09 SURVEYS AND LAYOUT

A. All work under this Contract shall be constructed in accordance with the lines and grades shown on the Drawings or as directed by the Engineer. Elevation of existing ground and appurtenances are believed to be reasonably correct but are not guaranteed to be absolute and therefore are presented only as an approximation. Any error or apparent discrepancy in the data shown or omissions of data required for accurately accomplishing the stake out survey shall be referred immediately to the Engineer for interpretation or correction.

B. All survey work for construction control purposes shall be made by the Contractor at his expense. The Contractor shall provide a Licensed Surveyor as Chief of Party, competently qualified men, all necessary instruments, stakes, and other material to perform the work.

C. Contractor shall establish all baselines for the location of the principal component parts of the work together with a suitable number of bench marks and batter boards adjacent to the work. Based upon the information provided by the Contract Drawings, the Contractor shall develop and make all detail surveys necessary for construction, including slope stakes, batter boards, stakes for all working points, lines and elevations.

D. Contractor shall have the responsibility to carefully preserve the bench marks, reference points and stakes, and in the case of destruction thereof by the Contractor or resulting from his negligence, the Contractor shall be charged with the expense and damage resulting therefrom and shall be responsible for any mistakes that may be caused by the unnecessary loss or disturbance of such bench marks, reference points and stakes.

E. Existing or new control points, property markers and monuments that will be or are destroyed during the normal causes of construction shall be reestablished by the Contractor and all reference ties recorded therefore shall be furnished to the Engineer. All computations necessary to establish the exact position of the work shall be made and preserved by the Contractor.

F. The Engineer may check all or any portion of the work and the Contractor shall afford all necessary assistance to the Engineer in carrying out such checks. Any necessary corrections to the work shall be immediately made by the Contractor. Such checking by the Engineer shall not relieve the Contractor of any responsibilities for the accuracy or completeness of his work.

G. At completion of the work, the Contractor shall furnish Record Drawings indicating the final layout of all structures, roads, all structures, existing bench marks, etc. The Record Drawings shall indicate all critical elevations of piping, structures, finish grades, etc.

H. Contractor shall have all structures and improvements surveyed by a licensed land surveyor and adjusted to match specified elevations as shown on the Contract Drawings. Final elevations shall be set to within a tolerance of +/- 0.05 inches of specified elevation. If a greater tolerance is allowed, it will be noted on the Contract Drawings. A final report showing all specified and surveyed elevations shall be certified by the surveyor and delivered to the Engineer.

1.10 FIRE PROTECTION

A. Contractor shall take all necessary precautions to prevent fires at or adjacent to the work, buildings, etc., and shall provide adequate facilities for extinguishing fires which do occur. Burning, if permitted in Division 2, shall be limited to areas approved by the Engineer and Owner and properly controlled by the Contractor.

B. When fire or explosion hazards are created in the vicinity of the work as a result of the locations of fuel tanks, or similar hazardous utilities or devices, the Contractor shall immediately alert the local Fire Marshal, the Engineer, and the Owner of such tank or device. The Contractor shall exercise all safety precautions and shall comply with all instructions issued by the Fire Marshal and shall cooperate with the Owner of the tank or device to prevent the occurrence of fire or explosion.

1.11 CHEMICALS

A. All chemicals used during project construction or furnished for project operation, whether herbicide, pesticide, disinfectant, polymer, or reactant of other classification, must show approval of either the EPA or USDA. Use of all such chemicals and disposal of residues shall be in strict conformance with all applicable rules and regulations.

1.12 FIRST AID FACILITIES AND ACCIDENTS

A. First Aid Facilities

1. The Contractor shall provide at the site such equipment and facilities as are necessary to supply first aid to any of his personnel who may be injured in connection with the work.

B. Accidents

1. The Contractor shall promptly report, in writing, to the Engineer and Owner all accidents whatsoever out of, or in connection with, the performance of the work, whether on or adjacent to the site, which cause death, personal injury or property damage, giving full details and statements of witnesses.

2. If death, serious injuries, or serious damages are caused, the accident shall be reported immediately by telephone or messenger to both the Owner and the Engineer.

3. If any claim is made by anyone against the Contractor or a Subcontractor on account of any accidents, the Contractor shall promptly report the facts, in writing, to the Engineer and Owner, giving full details of the claim.

1.13 ULTIMATE DISPOSITION OF CLAIMS BY ONE CONTRACTOR ARISING FROM ALLEGED DAMAGE BY ANOTHER CONTRACTOR

A. During the progress of the work, other Contractors may be engaged in performing other work or may be awarded other Contracts for additional work on this project. In that event, the Contractor shall coordinate the work to be done hereunder with the work of such other Contractors and the Contractor shall fully cooperate with such other Contractors and carefully fit its own work to that provided under other Contracts as may be directed by the Engineer. The Contractor shall not commit or permit any act which will interfere with the performance of work by any other Contractor.

B. If the Engineer shall determine that the Contractor is failing to coordinate his work with the work of the other Contractors as the Engineer directed, then the Owner shall have the right to withhold any payments otherwise due hereunder until the Contractor completely complies with the Engineer's directions.

C. If the Contractor notifies the Engineer in writing that another Contractor is failing to coordinate his work with the work of this Contract as directed, the Engineer will promptly investigate the charge. If the Engineer finds it to be true, he will promptly issue such directions to the other Contractor with respect thereto as the situation may require. The Owner, the Engineer, nor any of their agents shall not, however, be liable for any damages suffered by the Contractor by reason of the other Contractor's failure to promptly comply with the directions so issued by the Engineer, or by reason of another Contractor's default in performance, it being understood that the Owner does not guarantee the responsibility or continued efficiency of any Contractor.

D. The Contractor shall indemnify and hold the Owner and the Engineer harmless from any and all claims of judgments for damages and from costs and expenses to which the Owner may be subjected or which it may suffer or incur by reason of the Contractor's failure to comply with the Engineer's directions promptly.

E. Should the Contractor sustain any damage through any act or omission of any other Contractor having a Contract with the Owner for the performance of work upon the site or of work which may be necessary to be performed for the proper execution of the work to be performed hereunder, or through any act or omission of a Subcontractor of such Contract, the Contractor shall have no claim against the Owner or the Engineer for such damage, but shall have a right to recover such damage from the other Contractor under the provision similar to the following provisions which have been or will be inserted in the Contracts with such other Contractors.

F. Should any other Contractor having or who shall hereafter have a Contract with the Owner for the performance of work upon the site sustain any damage through any act or omission of the Contractor hereunder or through any act or omission of any Subcontractor of the Contractor, the Contractor agrees to reimburse such other Contractor for all such damages and to defend at his own expense any suit based upon such claim and if any judgment or claims against the Owner shall be allowed, the Contractor shall pay or satisfy such judgment or claim and pay all costs and expenses in connection therewith and shall indemnify and hold the Owner harmless from all such claims.

G. The Owner's right to indemnification hereunder shall in no way be diminished, waived or discharged, by its recourse to assessment of liquidated damages as provided in the Contract, or by the exercise of any other remedy provided for by Contract Documents or by law.

1.14 BLASTING AND EXPLOSIVES

A. THE USE OF BLASTING OR EXPLOSIVES SHALL NOT BE ALLOWED UNDER THIS PROJECT.

1.15 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.

1.16 WEATHER CONDITIONS

A. No work shall be done when the weather is unsuitable. The Contractor shall take necessary precautions (in the event of impending storms) to protect all work, materials, or equipment from damage or deterioration due to floods, driving rain, or wind, and snow storms. The Owner reserves the right, through the opinion of the Engineer, to order that additional protection measures over and beyond those proposed by the Contractor, be taken to safeguard all components of the Project. The Contractor shall not claim any compensation for such precautionary measures so ordered, nor claim any compensation from the Owner for damage to the work from weather elements.

B. The mixing and placing of concrete or pavement courses, the laying of masonry, and installation of sewers and water mains shall be stopped during rainstorms, if ordered by the Engineer; and all freshly placed work shall be protected by canvas or other suitable covering in such manner as to prevent running water from coming in contact with it. Sufficient coverings shall be provided and kept ready at hand for this purpose. The limitations and requirements for mixing and placing concrete, or laying of masonry, in cold weather shall be as described elsewhere in these Specifications.

## 1.17 PERIODIC CLEANUP: BASIC SITE RESTORATION

A. During construction, the Contractor shall regularly remove from the site of the work all accumulated debris and surplus materials of any kind which result from his operations. Unused equipment and tools shall be stored at the Contractor's yard or base of operations for the Project.

B. When the work involves installation of sewers, drains, water mains, manholes, underground structures, or other disturbance of existing features in or across streets, rights-of-way, easements, or private property, the Contractor shall (as the work progresses) promptly backfill, compact, grade, and otherwise restore the disturbed area to the basic condition which will permit resumption of pedestrian or vehicular traffic and any other critical activity or functions consistent with the original use of the land. The requirements for temporary paving of streets, walks, and driveways are specified elsewhere. Unsightly mounds of earth, large stones, boulders, and debris shall be removed so that the site presents a neat appearance.

C. The Contractor shall perform the cleanup work on a regular basis and as frequently as ordered by the Engineer. Basic site restoration in a particular area shall be accomplished immediately following the installation or completion of the required facilities in that area. Furthermore, such work shall also be accomplished, when ordered by the Engineer, if partially completed facilities must remain incomplete for some time period due to unforeseen circumstances.

D. Upon failure of the Contractor to perform periodic cleanup and basic restoration of the site to the Engineer's satisfaction, the Owner may, upon five (5) days prior written notice to the Contractor, without prejudice to any other rights or remedies of the Owner, cause such work for which the Contractor is responsible to be accomplished to the extent deemed necessary by the Engineer, and all costs resulting therefrom shall be charged to the Contractor and deducted from the amounts of money that may be due him.

## 1.18 USE OF FACILITIES BEFORE COMPLETION

A. The Owner reserves the right to enter and use any portion of the constructed facilities before final completion of the whole work to be done under this Contract. However, only those portions of the facilities which have been completed to the Engineer's satisfaction, as evidenced by his issuing a Certificate of Substantial Completion covering that part of the work, shall be placed in service.

B. It shall be the Owner's responsibility to prevent premature connections to or use of any portion of the installed facilities by private or public parties, persons or groups of persons, before the Engineer issues his Certificate of Substantial Completion covering that portion of the work to be placed in service.

C. Consistent with the approved progress schedule, the Contractor shall cooperate with the Owner, his agents, and the Engineer to accelerate completion of those facilities, or portions thereof, which have been designated for early use by the Owner.

1.19 CONSTRUCTION VIDEO

A. The Contractor shall video the entire project site including all concrete and asphalt pavements, curb and gutter, fencing to remain, structures to be demolished, and existing structures that are to be modified. The original video image shall be turned over to the Engineer prior to beginning construction activities. The video shall be provided as an Audio Video Interleave File (.avi) and shall be provided on DVD+R/DVD-ROM compatible media only. The video shall clearly identify existing site and structural conditions prior to construction.

PART 2 -- PRODUCTS

(NOT USED)

PART 3 -- EXECUTION

(NOT USED)

- END OF SECTION -

SECTION 01025

MEASUREMENT AND PAYMENT

PART 1 -- GENERAL

1.01 SCOPE OF WORK

A. The items listed below, beginning with 1.03 GENERAL CONSTRUCTION, refer to and are the same pay items listed in the Bid Form Table. They constitute all of the pay items for the completion of the Work. No direct or separate payment will be made for providing miscellaneous temporary or accessory works, services, layout surveys, job signs, sanitary requirements, safety devices, approval and record drawings, water supplies, power, maintaining traffic, removal of waste, watchmen, and other requirements of the General Conditions, Supplementary Conditions, Special Conditions, Instructions to Bidders, and the General Requirements. Compensation for all such services, things and materials shall be included in the prices stipulated for the lump sum and unit price pay items listed herein.

B. Each lump sum and unit bid price will be deemed to include an amount considered by the Contractor to be adequate to cover the Contractor's overhead and profit for each separately identified item.

1.02 ENGINEER'S ESTIMATE OF QUANTITIES

A. The Engineer's estimated quantities for unit price pay items, as listed in the Bid Form Table, are approximate and are included solely for the purpose of comparison of Bids. The Owner does not expressly or by implication agree that the nature of the Work encountered or the actual quantities of material required will correspond therewith and reserves the right to increase or decrease any quantity or to eliminate any quantity as the Owner may deem necessary.

1.03 GENERAL CONSTRUCTION

A. Lump Sum Pay Items

1. Lump Sum for All Construction Work not Otherwise Included in the Unit Price Items.

Measurement and Payment: The lump sum payment will be full compensation for completing all work (including all permitting costs), as shown on the Drawings and specified in the Bidding and Contract Requirements and under Divisions 1 through 17, not otherwise included in unit price items.

B. Unit Price Pay Items

1. Force Main and Gravity Sewer Construction

MEASUREMENT OF QUANTITIES

a) Measurement by Weight: Measured by scale weight.

b) Measurement by Volume: Measured by cubic dimension using mean length, width, and height or thickness.

c) Measurement by Area: Measured by square dimension using mean length and width or radius.

d) Linear Measurement: Measured by linear dimension, at the item centerline.

e) Stipulated Sum/Price Measurement: Items measured as a completed item or unit of the Work.

PAYMENT

a) Payment Includes: Full compensation for all required labor, products, tools, equipment, plant, transportation, services and incidentals; erection, application or installation of an item of the Work; overhead and profit.

b) Final payment for Work governed by unit prices will be made on the basis of the actual measurements and quantities accepted by the Engineer multiplied by the unit price for Work which is incorporated in or made necessary by the Work.

2. Allowance Items

The Bid includes an allowance for payment by the Contractor to local and state Authorities to obtain permits required to do this work. The allowance amount is to be added to the Total Bid for Project. Any unused portion of the allowance remaining at the completion of the contract shall revert to the Owner as a credit. The allowance is for permits ONLY and shall not include any mark-up.

1.04 NON-PAYMENT FOR REJECTED PRODUCTS

A. Payment will not be made for any of the following:
1. Products wasted or disposed of in a manner that is not acceptable.
2. Products determined as unacceptable before or after placement.
3. Products not completely unloaded from the transporting vehicle.
4. Products placed beyond the lines and levels of the required Work.
5. Products remaining on hand after completion of the Work.
6. Loading, hauling, and disposing of rejected Products.

B. The CONTRACTOR is advised that the permits to construct on public rights-of-way are contingent upon the CONTRACTOR maintaining an acceptable level of repair to damaged

structures, appearance of the areas of construction, access to private property, and maintenance of drainage during the construction. The CONTRACTOR shall keep the Work as complete as close as possible (500 feet maximum) to the forward progress of the Work. Completeness of the Work shall include cleanup, grading, restoration, and seeding. Failure of the CONTRACTOR to maintain an acceptable level of completion in the Work may result in a reduction in the amount of approved payment in the CONTRACTOR'S Application of Payment. The amount of reduction for individual line items will be solely at the discretion of the OWNER/ENGINEER.

- END OF SECTION -

SECTION 01045

CUTTING AND PATCHING

PART 1 -- GENERAL

1.01 SECTION INCLUDES

A. Requirements and limitations for cutting and patching of Work.

1.02 RELATED SECTIONS

A. Section 01300 – Submittals

B. Section 01600 – Material and Equipment

C. Individual Product Specification Sections:

1. Cutting and patching incidental to work of the section.
2. Advance notification to other sections or openings required in work of those sections.
3. Limitations on cutting.

1.03 SUBMITTALS

A. Submit written request in advance of cutting or alteration which affects:
1. Structural integrity of any element of Project.
2. Integrity of weather exposed or moisture resistant element.
3. Efficiency, maintenance, or safety of any operational element.
4. Visual qualities of sight exposed elements.
5. Work of Owner or separate Contractor.

B. Include in request:
1. Identification of Project.
2. Location and description of affected Work.
3. Necessity for cutting or alteration.
4. Description of proposed Work and Products to be used.
5. Alternatives to cutting and patching.
6. Effect of Work on Owner or separate Contractor.
7. Written permission of affected separate Contractor.
8. Date and time Work will be executed.

PART 2 -- PRODUCTS

2.01 MATERIALS

A. Primary Products: Those required for original installation.

B. Product Substitution: For any proposed change in materials, submit request for substitution described in Section 01600.

PART 3 -- EXECUTION

3.01 EXAMINATION

A. Examine existing conditions prior to commencing Work, including elements subject to damage or movement during cutting and patching.

B. After uncovering existing Work, assess conditions affecting performance of work.

C. Beginning of cutting or patching means acceptance of existing conditions.

3.02 PREPARATION

A. Provide temporary supports to ensure structural integrity of the Work. Provide devices and methods to protect other portions of Project from damage.

B. Provide protection from elements for areas which may be exposed by uncovering work.

C. Maintain excavations free of water.

3.03 CUTTING

A. Execute cutting and fitting, including excavation and fill, to complete Work.

B. Uncover work to install improperly sequenced work.

C. Remove and replace defective or non-conforming work.

D. Remove samples of installed work for testing when requested.

E. Provide openings in the Work for penetration of mechanical and electrical work.

F. Employ original installer to perform cutting for weather exposed and moisture resistant elements, and sight exposed surfaces.

G. Cut rigid materials using masonry saw or core drill. Pneumatic tools are not allowed without prior approval.

3.04 PATCHING

A. Execute patching to complement adjacent Work.

B. Fit Products together to integrate with other Work.

C. Execute work by methods to avoid damage to other Work, and which will provide appropriate surfaces to receive patching and finishing.

D. Employ original installer to perform patching for weather exposed and moisture resistant elements, and sight exposed surfaces.

E. Restore work with new Products in accordance with requirements of Contract Documents.

F. Fit work to pipes, sleeves, ducts, conduit, and other penetrations through surfaces.

G. Refinish surfaces to match adjacent finish. For continuous surfaces, refinish to nearest intersection or natural break. For an assembly, refinish entire unit.

- END OF SECTION -

SECTION 01090

REFERENCE STANDARDS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Wherever reference is made to any published standards, codes, or standard specifications, it shall mean the latest standard code, specification, or tentative specification of the technical society, organization, or body referred to, which is in effect at the date of invitation for Bids.

B. All materials, products, and procedures used or incorporated in the work shall be in strict conformance with applicable codes, regulations, specifications, and standards.

C. A partial listing of codes, regulations, specifications, and standards includes the following:

Air Conditioning and Refrigeration Institute (ARI)

Air Diffusion Council (ADC)

Air Moving and Conditioning Association (AMCA)

The Aluminum Association (AA)

American Architectural Manufacturers Association (AAMA)

American Concrete Institute (ACI)

American Gear Manufacturers Association (AGMA)

American Hot Dip Galvanizers Association (AHDGA)

American Institute of Steel Construction, Inc. (AISC)

American Iron and Steel Institute (AISI)

American National Standards Institute (ANSI)

American Society of Civil Engineers (ASCE)

American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE)

American Society of Mechanical Engineers (ASME)

American Society for Testing and Materials (ASTM)

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American Standards Association (ASA)

American Water Works Association (AWWA)

American Welding Society (AWS)

American Wood-Preserver's Association (AWPA)

Anti-Friction Bearing Manufacturers Association (AFBMA)

Building Officials and Code Administrators (BOCA)

Conveyor Equipment Manufacturers Association (CEMA)

Consumer Product Safety Commission (CPSC)

Factory Mutual (FM)

Federal Specifications

Instrument Society of America (ISA)

Institute of Electrical and Electronics Engineers (IEEE)

National and Local Fire Codes

Lightning Protection Institute (LPI)

National Electrical Code (NEC)

National Electrical Manufacturer's Association (NEMA)

National Electrical Safety Code (NESC)

National Electrical Testing Association (NETA)

National Fire Protection Association (NFiPA)

Regulations and Standards of the Occupational Safety and Health Act (OSHA)

Southern Building Code Congress International, Inc. (SBCCI)

Sheet Metal & Air Conditioning Contractors National Association (SMACCNA)

Standard Building Code

Standard Mechanical Code

Standard Plumbing Code

Uniform Building Code (UBC)

Underwriters Laboratories Inc. (UL)

D. Contractor shall, when required, furnish evidence satisfactory to the Engineer that materials and methods are in accordance with such standards where so specified.

E. In the event any questions arise as to the application of these standards or codes, copies shall be supplied on-site by the Contractor.

PART 2 -- PRODUCTS

(NOT USED)

PART 3 -- EXECUTION

(NOT USED)

- END OF SECTION -

SECTION 01200

PROJECT MEETINGS

PART 1 -- GENERAL

1.01 PRECONSTRUCTION MEETING

A. A preconstruction meeting will be held after Award of Contract, but prior to starting work at the site.

B. Attendance:

1. Owner

2. Engineer

3. Contractor

C. Minimum Agenda:

1. Execution of Agreement

2. Distribution of Contract Documents

3. Submission of Schedule of Values and Project Schedule

4. Critical work sequencing

5. Designation of personnel representing the Owner and Contractor

6. Procedures and processing of field decisions, submittals, substitutions, applications for payment, proposal request, and Change Orders

7. Security and housekeeping procedures

8. Procedures for testing

9. Procedures for maintaining record documents

10. Requirements for system start-up

11. Contract closeout procedures

1.02 PROGRESS MEETING

A. Progress meetings will be held monthly at the Berkeley County Water and Sanitation Engineering Conference Room during the performance of the work of this Contract. Additional meetings may be called as progress of work dictates.
B. Engineer will preside at meetings and record minutes of proceedings and decisions. Engineer will distribute copies of minutes to participants.

C. Attendance:

1. Owner

2. Engineer

3. Contractor

4. Subcontractors, only with Engineer's approval or request, as pertinent to the agenda

D. Minimum Agenda:

1. Review and approve minutes of previous meetings.

2. Review progress of Work since last meeting.

3. Review proposed 30-60 day construction schedule.

4. Note and identify problems which impede planned progress.

5. Develop corrective measures and procedures to regain planned schedule.

6. Revise construction schedule as indicated and plan progress during next work period.

7. Schedule next progress meeting.

PART 2 -- PRODUCTS

(NOT USED)

PART 3 -- EXECUTION

(NOT USED)

- END OF SECTION -

SECTION 01300

SUBMITTALS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Progress Schedule

1. The Contractor shall prepare and submit an electronic copy of his proposed progress schedule to the Engineer for review and approval in accordance with Section 0700..

2. If so required, the schedule shall be revised until it is approved by the Engineer.

3. Schedule shall be updated monthly, depicting progress to the last day of the month and an electronic copy submitted to the Engineer not later than the fifth day of the month, and prior to the application for progress payment. Failure to provide monthly schedule updates will be grounds for the Engineer or Owner to withhold progress payment approval. Paper copies of the schedule shall be provided for distribution at the progress meetings.

4. Schedule shall be prepared in the form of a horizontal bar chart showing in detail the proposed sequence of the work and identifying construction activities for each structure and for each portion of work.

5. Schedule shall be time scaled, identifying the first day of each week. The Schedule shall be provided with estimated dates for Early Start, Early Finish, Late Start and Late Finish. The work shall be scheduled to complete the Project within the Contract time. The Late Finish date shall equal the Contract Completion Date.

6. Schedule shall show duration (number of days) and float for each activity. Float shall be defined as the measure of leeway in starting or completing a scheduled activity without adversely affecting the project completion date established by the Contract Documents.

7. Updated schedule shall show all changes since the previous submittal.

8. All revisions to the schedule must have the prior approval of the Engineer.

B. Equipment and Material Orders Schedule

1. Contractor shall prepare an electronic copy of his schedule of principal items of equipment and materials to be purchased to the Engineer for review and approval.

2. If so required, the schedule shall be revised until it is approved by the Engineer.

3. Schedule shall be updated monthly and an electronic copy submitted to the Engineer not later than the fifth day of every month with the application for progress payment.

4. The updated schedule shall be based on the Progress Schedule developed under the requirements of Paragraph 1.01(A) of this Section.

5. Schedule shall be in tabular form with appropriate spaces to insert the following information for principal items of equipment and materials:

    a. Dates on which Shop Drawings are requested and received from the manufacturer.

    b. Dates on which certification is received from the manufacturer and transmitted to the Engineer.

    c. Dates on which Shop Drawings are submitted to the Engineer and returned by the Engineer for revision.

    d. Dates on which Shop Drawings are revised by manufacturer and resubmitted to the Engineer.

    e. Date on which Shop Drawings are returned by Engineer annotated either "Furnish as Submitted" or "Furnish as Corrected".

    f. Date on which accepted Shop Drawings are transmitted to manufacturer.

    g. Date of manufacturer's scheduled delivery.

    h. Date on which delivery is actually made.

C. Working Drawings

1. Within fifteen (15) days after the Notice to Proceed, the Contractor shall prepare an electronic copy of his preliminary schedule of Working Drawing submittals to the Engineer for review and approval. If so required, the schedule shall be revised until it is approved by the Engineer.

2. Working Drawings include, but are not limited to, Shop Drawings, layout drawings in plan and elevation, installation drawings, elementary wiring diagrams, interconnecting wiring diagrams, manufacturer's data, etc. Contractor shall be responsible for securing all of the information, details, dimensions, Drawings, etc., necessary to prepare the Working Drawings required and necessary under this Contract and to fulfill all other requirements of his Contract. Contractor shall secure such information, details, Drawings, etc., from all possible sources including the Drawings, Working Drawings prepared by subcontractors, Engineers, suppliers, etc.

3. Working Drawings shall accurately and clearly present the following:

a. All working and installation dimensions.

b. Arrangement and sectional views.

c. Units of equipment in the proposed positions for installation, details of required attachments and connections, and dimensioned locations between units and in relation to the structures.

d. Necessary details and information for making connections between the various trades including, but not limited to, power supplies and interconnecting wiring between units, accessories, appurtenances, etc.

4. In the event that the Engineer is required to provide additional engineering services as a result of a substitution of materials or equipment by the Contractor, the additional services will be provided in accordance with Sections 00520 and 00700, and will be covered in supplementary or revised Drawings which will be issued to the Contractor. All changes indicated that are necessary to accommodate the equipment and appurtenances shall be incorporated into the Working Drawings submitted to the Engineer.

5. Working Drawings specifically prepared for this Project shall be submitted electronically. Working Drawings shall conform to recognized drafting standards and be neat, legible and drawn to a large enough scale to show in detail the required information.

6. Shop Drawings

a. Contractor shall submit for review by the Engineer Shop Drawings for all fabricated work and for all manufactured items required to be furnished by the Contract Documents.

b. Structural and all other layout Drawings prepared specifically for the Project shall have a plan scale of not less than 1/4-inch = 1 foot.

c. Where manufacturer's publications in the form of catalogs, brochures, illustrations or other data sheets are submitted in lieu of prepared Shop Drawings, such submittals shall specifically indicate the item for which approval is requested. Identification of items shall be made in ink, and submittals showing only general information are not acceptable.

d. Electrical submittals shall meet the requirements herein and as indicated in Section 16000, 1.05.

7. Layout and Installation Drawings

a. Contractor shall prepare and submit for review by the Engineer layout and installation drawings for all pipes, valves, fittings, sewers, all electrical and other conduits, instrumentation, interconnection wiring diagrams, communications, power supply, alarm circuits, etc., under this Contract. The

final dimensions, elevations, locations, etc., of pipes, valves, fittings, sewers, conduits, equipment, etc., may depend upon the dimensions of equipment and valves to be furnished by the Contractor.

b. Layout and installation drawings are required for both interior and exterior piping, valves, fittings, sewers, drains, heating and ventilation ducts, conduits, plumbing lines, electrical cable trays, etc.

c. Layout and installation Drawings shall show connections to structures, equipment, sleeves, valves, fittings, etc.

d. Drawings shall show the location and type of all supports, hangers, foundations, etc., and the required clearances to operate valves, equipment, etc.

e. The Drawings for pipes, ducts, conduits, etc., shall show all 3-inch and larger electrical conduits and pressure piping, electrical cable trays, heating and ventilation ducts or pipes, structure, manholes or any other feature within four (4) feet (measured as the clear dimension) from the pipe duct, conduit, etc., for which the profile is drawn.

8. Contractor Responsibilities

a. All submittals from subcontractors, manufacturers or suppliers shall be sent directly to the Contractor for checking. Contractor shall thoroughly check all Drawings for accuracy and conformance to the intent of the Contract Documents. Drawings found to be inaccurate or otherwise in error shall be returned to the subcontractors, manufacturers, or suppliers by the Contractor for correction before submitting them to the Engineer.

b. Submittals shall be submitted electronically where possible. All submittals shall be dated, properly labeled and consecutively numbered. Submittals shall be numbered with the specification section first followed by consecutive numbers. Resubmittals shall retain original submittal number followed by a sequential alphabetical suffix. Information on the label shall indicate Specification Section, Drawing number, subcontractor's, manufacturer's, or supplier's name and the name or type of item the submittal covers. Each part of a submittal shall be marked and tabulated.

c. Working Drawings shall be submitted as a single complete package including all associated drawings relating to a complete assembly of the various parts necessary for a complete unit or system.

d. Shop Drawings shall be submitted as a single complete package for any operating system and shall include all items of equipment and any mechanical units involved or necessary for the functioning of such system. Where applicable, the submittal shall include elementary wiring diagrams showing circuit functioning and necessary interconnection wiring diagrams for construction.

e. ALL SUBMITTALS SHALL BE THOROUGHLY CHECKED BY THE CONTRACTOR FOR ACCURACY AND CONFORMANCE TO THE INTENT OF THE CONTRACT DOCUMENTS BEFORE BEING SUBMITTED TO THE ENGINEER AND SHALL BEAR THE CONTRACTOR'S STAMP OF APPROVAL CERTIFYING THAT THEY HAVE BEEN SO CHECKED. SUBMITTALS WITHOUT THE CONTRACTOR'S STAMP OF APPROVAL WILL NOT BE REVIEWED BY THE ENGINEER AND WILL BE RETURNED TO THE CONTRACTOR.

f. If the submittals contain any departures from the Contract Documents, specific mention thereof shall be made in the Contractor's letter of transmittal. Otherwise, the review of such submittals shall not constitute approval of the departure.

g. No materials or equipment shall be ordered, fabricated, shipped or any work performed until the Engineer returns to the Contractor the submittals, herein required, annotated "Furnish as Submitted", "Furnish as Corrected", or "Furnish as Corrected – Confirm." If a submittal is returned "Furnish as Corrected – Confirm" the portions of work covered by the submittal that require confirmation by the Engineer shall not be ordered, fabricated, shipped, or any work performed until those portions are approved in a subsequent submittal either "Furnish as Submitted" or "Furnish as Corrected".

h. Where errors, deviations, and/or omissions are discovered at a later date in any of the submittals, the Engineer's prior review of the submittals does not relieve the Contractor of the responsibility for correcting all errors, deviations, and/or omissions.

9. Procedure for Review

a. Submittals shall be transmitted in sufficient time to allow the Engineer at least seven (7) working days for review and processing.

b. Contractor shall submit electronically, all technical data or drawing to be reviewed.

c. Submittal shall be accompanied by a letter of transmittal containing date, project title, Contractor's name, number and titles of submittals, a list of relevant specification sections, notification of departures from any Contract requirement, and any other pertinent data to facilitate review.

d. Submittals will be annotated by the Engineer in one of the following ways:

"Furnish as Submitted" (FAS) - no exceptions are taken

"Furnish as Corrected" (FAC) - minor corrections are noted and shall be made.

"Furnish as Corrected – Confirm" (FACC) - some corrections are noted and a partial resubmittal or additional information are required as specifically requested.

"Revise and Resubmit" (R&R) - major corrections are noted and a full resubmittal is required.

"For Information Only – Not Reviewed" (FIO) – submittal was received and was distributed for record purposes without review.

e. If a submittal is satisfactory to the Engineer in full or in part, the Engineer will annotate the submittal "Furnish as Submitted", "Furnish as Corrected", or "Furnish as Corrected – Confirm", and return to the Contractor. If reproducible transparencies are submitted, the Engineer will retain the copies and return the reproducible transparencies to the Contractor. In the case of "Furnish as Corrected – Confirm" a partial resubmittal or additional information are required as specifically requested.

f. If a full resubmittal is required, the Engineer will annotate the submittal "Revise and Resubmit" and transmit to the Contractor for appropriate action.

g. Contractor shall continue to resubmit submittals in part if they are returned "Furnish as Corrected – Confirm" or in full if they are returned "Revise and Resubmit" as required by the Engineer until submittals are acceptable to the Engineer. It is understood by the Contractor that Owner may charge the Contractor the Engineer's charges for review in the event a submittal is not approved (either "Furnish as Submitted" or "Furnish as Corrected") by the third submittal for a system or piece of equipment. These charges shall be for all costs associated with engineering review, meetings with the Contractor or manufacturer, etc., commencing with the fourth submittal of a system or type of equipment submitted for a particular Specification Section.

h. Acceptance of a Working Drawing by the Engineer will constitute acceptance of the subject matter for which the Drawing was submitted and not for any other structure, material, equipment or appurtenances indicated or shown.

10. Engineer's Review

a. Engineer's review of the Contractor's submittals shall in no way relieve the Contractor of any of his responsibilities under the Contract. An acceptance of a submittal shall be interpreted to mean that the Engineer has no specific objections to the submitted material, subject to conformance with the Contract Drawings and Specifications.

b. Engineer's review will be confined to general arrangement and compliance with the Contract Drawings and Specifications only, and will not be for the purpose of checking dimensions, weights, clearances, fittings, tolerances, interferences, coordination of trades, etc.

11. Record Working Drawings

a. Contractor shall maintain current record documents onsite for Owner's and Engineer's review including Working:
   i. Drawings, including Shop Drawings, for equipment, piping, electrical work, heating system, ventilating system, air conditioning system, instrumentation system, plumbing system, structural, interconnection wiring diagrams, etc.
   ii. Specifications
   iii. Addenda
   iv. Change Orders and other modifications to the Contract
   v. Reviewed Submittals
   vi. Manufacturer's recommendations for installation.

b. Fifteen (15) days prior to submitting final Application for Payment, the Contractor shall furnish the Engineer one complete set of all accepted Working Documents

c. Working Documents furnished shall be corrected to completely and accurately include any departures from previously accepted Documents

d. Record Documents to be stored separate from documents used for construction. Vertical and horizontal datum shall be NAVD88 and NAV83, respectively.

e. A description of the actual Products installed shall be legibly marked and recorded at each Product section of the Specifications, including the following:
   1. Manufacturer's name and product model and number
   2. Product substitutions or alternates utilized
   3. Changed made by Addenda and modifications.

f. Record Drawings and Submittals shall be legibly mark each item to record actual construction including:
   1. Measured depths of installation in relation to fixed datum.
   2. Measured horizontal and vertical locations of underground utilities and appurtenances, referenced to permanent surface improvements.
   3. Field changes of dimension and detail.
   4. Depth of conduits below concrete surface.

g. Details not on original Contract Drawings.

D. Operation and Maintenance Manuals

1. An electronic copy of preliminary Operation and Maintenance Manuals, prepared specifically for this Project, shall be furnished for each item of equipment furnished under this Contract. The preliminary manuals shall be provided to the Engineer not less than 60 days prior to the start-up of the respective equipment.

2. The preliminary manuals shall be reviewed by the Engineer prior to the Contractor submitting final copies for distribution to the Owner. Following review of the preliminary copies of the Operation and Maintenance Manuals, one (1) copy will be returned to the Contractor with required revisions noted, or the acceptance of the Engineer noted.

3. Manuals shall contain complete information in connection with assembly, operation, lubrication, adjustment, wiring diagrams and schematics, maintenance, and repair, including detailed parts lists with drawings or photographs identifying the parts.

4. Manuals furnished shall be assembled and bound in separate volumes, by major equipment items or trades, and properly indexed to facilitate locating any required information. In addition, manuals should be labeled in the front cover with the project, name, equipment description, and manufacturer contract information.

5. Engineer and the Owner shall be the sole judge of the acceptability and completeness of the manuals and may reject any submittal for insufficient information included, incorrect references and/or the manner in which the material is assembled.

6. Following the Engineer's review of the preliminary manuals, the Contractor shall submit five (5) paper copies and two (2) electronic copies of the final Operation and Maintenance Manuals to the Engineer. The manuals shall reflect the required revisions noted during the Engineer's review of the preliminary documents. Failure of the final manuals to reflect the required revisions noted by the Engineer during a review of the Preliminary documents will result in the manuals being returned to the Contractor. Acceptable final Operation and Maintenance Manuals shall be provided not less than two week prior to equipment start-up.

E. Certified Shop Test Reports

1. Each piece of equipment for which pressure, head, capacity, rating, efficiency, performance, function or special requirements are specified or implied shall be tested in the shop of the manufacturer in a manner which shall conclusively prove that its characteristics comply fully with the requirements of the Contract Documents and applicable test codes and standards. Contractor shall keep the Engineer advised of the scheduling of shop tests so that the Engineer may arrange for the witnessing or inspection at the proper time and place.

2. The Contractor shall secure from the manufacturers seven (7) copies of the actual test data, the interpreted results and a complete description of the testing facilities and testing setup, all accompanied by a certificate of authenticity sworn to by a responsible official of the manufacturing company and notarized. These reports shall be forwarded electronically to the Engineer for review.

3. In the event any equipment fails to meet the test requirements, the manufacturer shall make all necessary changes, adjustments or replacements and the tests shall be repeated, at no additional cost to the Owner or Engineer, until the equipment test requirements are acceptable to the Engineer.

4. No equipment shall be shipped to the Project until the Engineer notifies the Contractor, in writing, that the shop test reports are acceptable.

F. Samples

1. Contractor shall furnish for review all samples as required by the Contract Documents or requested by the Engineer.

2. Samples shall be of sufficient size or quantity to clearly illustrate the quality, type, range of color, finish or texture and shall be properly labeled to show the nature of the material, trade name of manufacturer and location of the work where the material represented by the sample will be used.

3. Samples shall be checked by the Contractor for conformance to the Contract Documents before being submitted to the Engineer and shall bear the Contractor's stamp of approval certifying that they have been so checked. Transportation charges on samples submitted to the Engineer shall be prepaid by the Contractor.

4. Engineer's review will be for compliance with the Contract Documents and his comments will be transmitted to the Contractor with reasonable promptness.

5. Accepted samples will establish the standards by which the completed work will be judged.

G. CONSTRUCTION VIDEO

A. The Contractor shall video the entire project site including all concrete and asphalt pavements, curb and gutter, fencing to remain, structures to be demolished, and existing structures that are to be modified. The original video image shall be turned over to the Engineer prior to beginning construction activities. The video shall be provided as an Audio Video Interleave File (.avi) and shall be provided on DVD+R/DVD-ROM compatible media only. The video shall clearly identify existing site and structural conditions prior to construction.

.

PART 2 -- PRODUCTS

(NOT USED)

PART 3 -- EXECUTION

(NOT USED)

- END OF SECTION -

SECTION 01350

SEISMIC ANCHORAGE AND BRACING

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Furnish all equipment, labor, materials, and services required to design and provide seismic restraint and bracing for all nonstructural architectural, mechanical, electrical, and plumbing components and their supports and attachments permanently attached to the primary structure in which the components are to be installed in accordance with the Contract Documents and the seismic restraint requirements of latest edition of ASCE standards.

B. Furnish mechanical, electrical, and plumbing equipment manufacturer certifications showing seismic compliance in accordance with the latest edition of ASCE standards for equipment designated as an essential component or to remain operational following a seismic event.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 01450 – Special Inspections

B. Section 05010 – Metal Materials

C. Section 05050 – Metal Fastening

D. Section 05061 – Stainless Steel

E. Section 05120 – Structural Steel

F. Section 05140 – Structural Aluminum

G. Section 06610 – Glass Fiber and Resin Fabrications

H. Section 15000 – Basic Mechanical Requirements

I. Section 15020 – Pipe Supports

J. Section 15400 – Plumbing

K. Section 15500 – HVAC Requirements

L. Section 16000 – Basic Electrical Requirements

M. Division 17 – Control and Information Systems

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N. Further requirements for seismic anchorage and bracing may be included in other Sections of the Specifications. See section for the specific item in question.

1.03 DEFINITIONS

A. Nonstructural components: All architectural, mechanical, electrical or plumbing elements or systems and their supports or attachments provided under this contract which are permanently attached to the floors, roof, walls, columns and beams of newly constructed buildings, building additions, existing buildings or non-building structures.

1. Architectural nonstructural components include, but are not limited to, interior nonstructural walls and partitions, exterior wall panels and glazing elements, glass curtain walls, skylights, cabinets, suspended ceilings, fascias, and cladding.

2. Mechanical nonstructural components include, but are not limited to, HVAC units, fans, water and wastewater treatment process equipment, instrumentation cabinets, piping and ductwork.

3. Electrical nonstructural components include, but are not limited to, conduit systems, cable tray systems, boxes, transformers, panelboards, switchboards, switchgear, busway, individual motor controllers, motor control centers, variable frequency drives, automatic transfer switches, and lighting systems.

4. Plumbing nonstructural components include, but are not limited to, sprinkler systems and associated piping, and sump pumps.

B. Seismic Restraint: Attachments and supports, including braces, frames, legs, hangers, saddles, and struts which anchor and brace nonstructural components to minimize their displacement during an earthquake and transmit loads between non-structural components and their attachments to the structure or building.

C. Attachment: Elements including anchor bolts, welded connections, and mechanical fasteners which secure non-structural components or supports to the structure.

D. Hazardous: Toxic, flammable, explosive or corrosive materials in excess of building code mandated threshold quantities for non-hazardous condition.

E. Essential Components: Nonstructural components considered necessary to public safety for which the importance factor $I_p$ applies, including:

1. Life safety systems which must function following an earthquake, including but not limited to, sprinklers for fire protection, emergency lighting, egress corridors and stairways, and smoke purge systems.

2. Components which contain, convey or support hazardous materials.

3. Components which are within or attached to an Occupancy or Risk Category IV structure as defined in ASCE 7 Chapter 1.

4. Process systems and elements designated below:

   a. Water storage facilities and water pumping systems required to maintain water pressure used for fire suppression.

   b. List specific critical systems where system failure could result in loss of life (e.g. large diameter piping under high pressure, etc) or that must remain operable following the design earthquake

   c. List nonstructural components that would otherwise be non-essential, but failure of the supports could result in consequential damage to essential components.

F. Nonbuilding Structures: All self-supporting structures which are supported by an independent foundation or by other structures which include, but are not limited to, storage tanks, silos, exhaust stacks, storage racks, and towers.

G. Delegated Design: Design of a structure or structural element(s) which has been deferred by the contract documents to be performed during the project construction stage, by a registered design professional retained by the contractor and with the design submitted as a shop drawing to the Engineer.

1.04 EXEMPTIONS

A. The following nonstructural components are exempt from requiring seismic anchorage and bracing:

1. All architectural, mechanical, electrical and plumbing nonstructural components in Seismic Design Category A.

2. All mechanical, electrical and plumbing nonstructural components in Seismic Design Category B.

3. All architectural nonstructural components in Seismic Design Category B provided $I_p = 1.0$, except parapets supported by bearing or shear walls.

4. All mechanical, electrical and plumbing nonstructural components in Seismic Design Category C provided $I_p = 1.0$.

5. All mechanical, electrical and plumbing nonstructural components in Seismic Design Category D, E or F provided all the following apply:

   a. $I_p = 1.0$.

   b. Components are positively attached to the structure without consideration of frictional resistance and have flexible connections between the components and associated ductwork, piping and conduit.

c. Either of the following:

i. Component center of mass is 4 ft or less above a floor level and weighs 400 lbs or less.

ii. Component weighs 20 lbs or less or 5 plf or less for distribution systems.

6. Other exemptions as allowed by the Specifications, Codes and Standards referenced herein.

1.05 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Without limiting the generality of the Specifications, all work herein shall conform to or exceed the applicable requirements of the following documents. The building code shall be the version in effect at the time of Bid within the jurisdiction where the Work is located. All other referenced specifications, codes, and standards refer to the version as referenced by the building code. If no version is referenced by the building code, then the most current issue available at the time of Bid shall be used.

1. International Building Code

2. ASCE/SEI 7 Minimum Design Loads for Buildings and Other Structures

3. NFPA 13 Standard for Installation of Sprinkler Systems

4. FEMA 412 Installing Seismic Restraints for Mechanical Equipment

5. FEMA 413 Installing Seismic Restraints for Electrical Equipment

6. FEMA 414 Installing Seismic Restraints for Duct and Pipe

7. SMACNA Sheet Metal and Air Conditioning Contractors' National Association, Seismic Restraint Manual: Guidelines for Mechanical Systems

8. ACI 318 Building Code Requirements for Structural Concrete and Commentary

9. ACI 355.2 Qualifications of Post-Installed Mechanical Anchors in Concrete

10. ACI 355.4 Qualifications of Post-Installed Adhesive Anchors in Concrete

1.06 SUBMITTALS

A. Submit the following in accordance with Section 01300, Submittals.

1. Seismic anchorage and bracing shop drawings for all architectural, mechanical, electrical, and plumbing nonstructural components, elements and systems not meeting any of the exemptions in paragraph 1.4 above and do not have a design for seismic anchorage and bracing provided within the contract documents. Submittals shall include the following:

a. Component manufacturer's cut sheets and fabrication details for equipment bases and foundations, including dimensions, structural member sizes, support point locations and equipment operational loads. Equipment anchorage details shall clearly indicate anchor size, pattern, embedment and edge distance requirements to satisfy operational and seismic forces. Details shall also indicate grout, bearing pads, isolators, etc required for complete installation.

b. Design calculations, signed and sealed by a Professional Engineer registered in the State of South Carolina confirming the proposed seismic restraints and attachment will provide sufficient strength and stiffness to resist the design earthquake and limit damage to nonstructural components and the entire support is sufficient to resist the combined gravity and seismic loads. Separate calculation submittals for vertical and lateral load support systems shall not be allowed.

c. Detailed Shop Drawings, signed and sealed by a Professional Engineer registered in the State of South Carolina, showing specific details of the support design including material, installation, attachments, connection hardware, etc, and the restraint layout and location of all hangers and supports (resisting both gravity and seismic loads), including restraint orientation and direction of force(s) to be resisted. Within each submittal, the Contractor shall include a **cumulative** set of hanger and support location drawings (one cumulative 'living drawing for each building structure) containing all proposed mechanical, electrical and plumbing support locations submitted to date showing the locations of all support attachments to the primary structure. Load magnitudes shall be indicated at attachments to the structure where the sum of the reaction loads on a single member exceeds 1000 pounds vertically or exceeds 500 pounds horizontally. Unless requested by the Engineer, load magnitudes need not be submitted for load values less than these stated values. Separate shop drawing submittals for vertical and lateral load support systems shall not be allowed.

d. For components required to be certified as seismically qualified in accordance with paragraph 1.06.A.2 below, submit installation guidelines provided by the equipment manufacturer for proper seismic mounting of the equipment.

2. For each mechanical, electrical and plumbing nonstructural components and systems furnished, including associated equipment appurtenances and attachments, designated as essential components in Seismic Design Categories C through F, provide Manufacturer's Certification signed and sealed by a registered Professional Engineer in the State of South Carolina to show the component is seismically qualified in accordance with the Specifications, Codes, and Standards requirements referenced herein. The following requirements shall be met:

   a. Seismic qualification shall be substantiated either by approved shake table testing or experience data, with the evidence of such qualification testing or experience data submitted to the Engineer along with the manufacturer's statement certifying the equipment shall remain operable following the design seismic event.

   b. Components with hazardous contents shall also be certified by the manufacturer to maintain containment following the design seismic event based on analysis, approved shake table testing, or experience data. Evidence demonstrating compliance shall be submitted to the Engineer.

   c. Seismic qualification testing shall be based on the latest edition of ASCE standards and on a nationally recognized testing standard procedure such as ICC-ES AC 156.

3. Seismic anchorage and bracing shop drawings for all architectural, mechanical, electrical, and plumbing nonstructural components, elements and systems that do not meet any of the exemptions in paragraph 1.4 above and do not have a design for seismic anchorage and bracing provided within the contract documents. Submittals shall include the following:

   a. Component manufacturer's cut sheets and fabrication details for equipment bases and foundations, including dimensions, structural member sizes, support point locations and equipment operational loads. Equipment anchorage details shall clearly indicate anchor size, pattern, embedment and edge distance requirements to satisfy operational and seismic forces. Details shall also indicate grout, bearing pads, isolators, etc required for complete installation.

   b. Design calculations, signed and sealed by a Professional Engineer registered in the State of South Carolina confirming the proposed seismic restraints and attachment will provide sufficient strength and stiffness to resist the design earthquake and limit damage to nonstructural components and that the entire support is sufficient to resist the combined gravity and seismic loads. Separate calculation submittals for vertical and lateral load support systems shall not be allowed.

   c. Detailed Shop Drawings, signed and sealed by a Professional Engineer registered in the State of South Carolina, showing specific details of the support design including material, installation, attachments, connection hardware, etc, and the restraint layout and location of all hangers and supports (resisting both gravity and seismic loads), including restraint

orientation and direction of force(s) to be resisted. Within each submittal, each Prime Contractor shall include a **cumulative** set of hanger and support location drawings (one cumulative 'living' drawing for each building structure) containing all proposed support locations which that Contractor has submitted to date showing the locations of all support attachments to the primary structure. Load magnitudes shall be indicated at attachments to the structure where the sum of all reaction loads on a single member (from all attachments of all Prime Contractors) exceeds 1000 pounds vertically or exceeds 500 pounds horizontally. Unless requested by the Engineer, load magnitudes need not be submitted for load values less than these stated values. Separate shop drawing submittals for vertical and lateral load support systems shall not be allowed.

d. For components required to be certified as seismically qualified in accordance with paragraph 1.06.A.2 below, submit installation guidelines provided by the equipment manufacturer for proper seismic mounting of the equipment.

4. For each mechanical, electrical and plumbing nonstructural components and systems furnished, including associated equipment appurtenances and attachments, designated as essential components in Seismic Design Categories C through F, provide Manufacturer's Certification signed and sealed by a registered Professional Engineer in the State of South Carolina to show the component is seismically qualified in accordance with the Specifications, Codes, and Standards requirements referenced herein. The following requirements shall be met:

   a. Seismic qualification shall be substantiated either by approved shake table testing or experience data, with the evidence of such qualification testing or experience data submitted to the Engineer along with the manufacturer's statement certifying the equipment shall remain operable following the design seismic event.

   b. Components with hazardous contents shall also be certified by the manufacturer to maintain containment following the design seismic event based on analysis, approved shake table testing, or experience data. Evidence demonstrating compliance shall be submitted to the Engineer.

   c. Seismic qualification testing shall be based on ASCE 7 and on a nationally recognized testing standard procedure such as ICC-ES AC 156.

1.07 DESIGN REQUIREMENTS

A. Seismic restraints systems for nonstructural components shall be subject to the most current local Building Code in conjunction with the seismic provisions of the International Building Code (IBC) Section 1613 and referenced ASCE 7 Chapter 13.

B. Seismic restraints systems for nonbuilding structures shall be subject to the most current local Building Code in conjunction with the seismic provisions of the International

Building Code (IBC) Section 1613 and referenced ASCE 7 Chapter 15,

C. Nonstructural components shall be assigned to the same Seismic Design Category as the structure they occupy or to which they are attached. Design of seismic support system and anchorage shall follow the site-specific seismic criteria noted on the drawings. Criteria shall include site-specific spectral response coefficients, site class, seismic design category, and risk category.

D. Component Importance Factor $I_p$ shall be 1.5 for all essential nonstructural components noted in item 1.03.E above. All other nonstructural components shall utilize $I_p$ = 1.0 unless noted otherwise.

E. Components shall be restrained and braced for earthquake forces both in the vertical and each orthogonal direction. Seismic restraint systems shall limit deflections of components per ASCE 7 and the displacements shall not impede component functionally and containment.

F. Anchorage shall be designed in accordance with ASCE 7. Mechanical fasteners used to secure nonstructural architectural, mechanical, electrical and plumbing components shall meet the requirements of Specification Section 05050. All mechanical fasteners used to anchor essential components and other elements so designated in Specification Section 05050 shall be considered Structural Anchors.

G. Avoid crossing structural expansion joints with seismic supports or bracing. Nonstructural components shall not be attached to multiple structure elements which may respond differently in an earthquake without provisions to accommodate independent movement. Flexible expansion loops or offsets, flexible joints, bellows type pipe expansion joints, couplings, etc shall be provided at structure expansion joints to allow for independent structure movement and thermal movement of piping, ductwork and conduit. Minimum movement capability in the vertical and each orthogonal direction shall equal the width of the joint.

H. Provide flexible connections, piping, conduit, etc at foundation levels where below grade utilities enter into the structure.

I. Design of support system for components with multiple attachments shall take into account the stiffness and ductility of the supporting members. Equipment designed as free-standing shall only be attached at its base. Use of non-free standing equipment requiring both vertical and lateral attachment is contingent upon loads applied to the structure and requires approval by the Engineer.

J. The seismic restraint design shall be based on actual equipment data (dimensions, weight, center of gravity, etc) obtained from the specifications or the approved equipment manufacturer. The equipment manufacturer shall verify the attachment points on the equipment can safely withstand the combination of seismic, self-weight and other loads imposed.

K. Attachments of nonstructural component supports and seismic restraints causing the building structure slabs, beams, walls, columns, etc. to be overstressed shall not be permitted.

L. Where the weight of a nonstructural component is greater than or equal to 25 percent of the effective seismic weight (as defined by ASCE 7) of the structure it is attached to, the component shall be classified as a nonbuilding structure and its support designed in accordance with ASCE 7 Chapter 15.

M. No reaction loads (either vertical or lateral) from nonstructural component supports and seismic restraints shall be allowed on any element where design has been delegated unless the additional loads on the element have been coordinated with the delegated designer and the submittal is accompanied by a sealed letter from the delegated designer indicating the element has been designed to support the reaction loads.

N. Reaction loads from nonstructural component supports and seismic restraints shall be transferred directly to the primary structural members, with no components supported from secondary members unless otherwise approved.

O. No holes shall be drilled into any structural steel for attachment of component supports without prior approval of the Engineer.

## PART 2 -- PRODUCTS

### 2.01 MATERIALS

A. Seismic restraints and braces shall be constructed of appropriate materials and connecting hardware to provide a continuous load path between the component and supporting structure of sufficient strength and stiffness to resist the calculated design seismic forces and displacements.

B. Component restraint, bracing and connection materials shall be compatible with and in general match the component and component gravity support materials. Contact between dissimilar metals shall be prevented. See Section 15020 – Pipe Supports for additional details.

C. Post-installed concrete anchors used for seismic restraint and bracing anchorage shall be considered structural anchors per Section 05050 and shall be prequalified for use in seismic applications.

D. Powder actuated fasteners in steel or concrete shall not be used for sustained tension loads in Seismic Design Categories D, E or F unless approved for seismic loading or specifically exempted by ASCE 7. Powder actuated fasteners in masonry shall not be used unless approved for seismic loading regardless of Seismic Design Category.

E. Friction clips shall not be used in Seismic Design Categories D, E or F for supporting sustained tension loads in combination with resisting seismic forces. C-type and large flange clamps may be used for hanger attachments provided restraining straps meeting NFPA 13 requirements are utilized and loosening of threaded connections is prevented by lock nuts, burred threads, etc.

PART 3 -- EXECUTION

3.01 INSTALLATION OF SEISMIC RESTRAINTS AND ANCHORAGES

A. No components, seismic anchorages or restraints shall be installed prior to review and acceptance by the Engineer and permitting agency.

B. Seismic certified equipment shall be installed per the manufacturer's recommendations. Fasteners shall meet manufacturer's requirements.

C. Following installation, all seismic restraints, bracing and seismically qualified equipment shall be inspected. See Specification Section 01450 for Special Inspection requirements.

- END OF SECTION -

SECTION 01400

QUALITY CONTROL

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Testing Laboratory Services

1. Laboratory testing and checking required by the Specifications, including the cost of transporting all samples and test specimens, shall be provided and paid for by the Contractor unless otherwise indicated in the Specifications.

2. Materials to be tested include, but are not necessarily limited to the following: cement, concrete aggregate, concrete, bituminous paving materials, structural and reinforcing steel, waterproofing, select backfill, crushed stone or gravel and sand.

3. Tests required by the Owner shall not relieve the Contractor from the responsibility of supplying test results and certificates from manufacturers or suppliers to demonstrate conformance with the Specifications.

4. Procedure

a. The Contractor shall plan and conduct his operations to permit taking of field samples and test specimens, as required, and to allow adequate time for laboratory tests.

b. The collection, field preparation and storage of field samples and test specimens shall be as directed by the Engineer with the cooperation of the Contractor.

5. Significance of Tests

a. Test results shall be binding on both the Contractor and the Owner, and shall be considered irrefutable evidence of compliance or noncompliance with the Specification requirements, unless supplementary testing shall prove, to the satisfaction of the Owner, that the initial samples were not representative of actual conditions.

6. Supplementary and Other Testing

a. Nothing shall restrict the Contractor from conducting tests he may require. Should the Contractor at any time request the Owner to consider such test results, the test reports shall be certified by an independent testing laboratory acceptable to the Owner. Testing of this nature shall be conducted at the Contractor's expense.

1.02 INSPECTION AND TESTS

A. The Contractor shall allow the Engineer ample time and opportunity for testing materials and equipment to be used in the work. He shall advise the Engineer promptly upon placing orders for material and equipment so that arrangements may be made, if desired, for inspection before shipment from the place of manufacture. The Contractor shall at all times furnish the Engineer and his representatives, facilities including labor, and allow proper time for inspecting and testing materials, equipment, and workmanship. The Contractor must anticipate possible delays that may be caused in the execution of his work due to the necessity of materials and equipment being inspected and accepted for use. The Contractor shall furnish, at his own expense, all samples of materials required by the Engineer for testing, and shall make his own arrangements for providing water, electric power, or fuel for the various inspections and tests of structures and equipment.

B. The Contractor shall furnish the services of representatives of the manufacturers of certain equipment, as prescribed in other Sections of the Specifications. The Contractor shall also place his orders for such equipment on the basis that, after the equipment has been tested prior to final acceptance of the work, the manufacturer will furnish the Owner with certified statements that the equipment has been installed properly and is ready to be placed in functional operation. Tests and analyses required of equipment shall be paid for by the Contractor, unless specified otherwise in the Section which covers a particular piece of equipment.

C. Where other tests or analyses are specifically required in other Sections of these Specifications, the cost thereof shall be borne by the party (Owner or Contractor) so designated in such Sections. The Owner will bear the cost of all tests, inspections, or investigations undertaken by the order of the Engineer for the purpose of determining conformance with the Contract Documents if such tests, inspection, or investigations are not specifically required by the Contract Documents, and if conformance is ascertained thereby. Whenever nonconformance is determined by the Engineer as a result of such tests, inspections, or investigations, the Contractor shall bear the full cost thereof or shall reimburse the Owner for said cost. In this connection, the cost of any additional tests and investigations, which are ordered by the Engineer to ascertain subsequent conformance with the Contract Documents, shall be borne by the Contractor.

PART 2 -- PRODUCTS

(NOT USED)

PART 3 -- EXECUTION

(NOT USED)

- END OF SECTION -

SECTION 01470

WATERTIGHTNESS TESTING OF PUMP STATION WETWELL

PART 1 – GENERAL (NOT USED)

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION

3.01 TEST PREPARATION

A. The design capability of the structure to withstand testing shall be verified for the pressures to be applied. Another type of test shall not be substituted for hydrostatic tightness testing without approval of the Engineer.

B. The structure shall not be tested before all elements of the structure which resist any portion of the retained liquid pressure are in place and the concrete has attained its specified compressive strength.

C. Unless otherwise specified, coatings shall not be applied until after the hydrostatic tightness testing is complete. Liners that are mechanically locked to the surface during the placement of the concrete shall be installed before the hydrostatic tightness testing. Interior liners shall be visually examined for deficiencies (pinholes, tears and partially fused splices) and must pass integrity testing. Deficiencies shall be prepared.

D. Clean the exposed concrete surfaces of the structure, including the floor, of all foreign material and debris. Prior to testing, standing water in or outside of the structure that would interfere with the inspection of the exposed concrete surfaces of the structure shall be removed.

E. The concrete surfaces and concrete joints shall be thoroughly inspected for potential leakage points. Areas of potential leakage shall be repaired before filling the containment structure with water.

F. All openings, fittings, and pipe penetrations in the structure shell shall be inspected at both faces of the concrete, if practical. Defective or cracked concrete shall be repaired prior to testing. All structural penetrations and inlet/outlets shall be securely sealed to prevent the loss of water from the structure during the test. All structural penetrations shall be monitored before and during the test to determine the watertightness of these appurtenances. If the structure is to be filled using the inlet/outlet pipe, positive means shall be provided to check that water is not entering or leaving through this pipe once the structure is filled to the test level. Leakage at these inlet/outlets shall be repaired prior to

testing. No allowance shall be made in test measurements for uncorrected known points of leakage

G. The flow from any underdrain system, if a system is provided, shall be monitored during this same period, and any increase in flow shall be recorded and considered for information as a part of the hydrostatic tightness testing.

H. The ground water level shall be brought to a level below the top of the base slab and kept at that elevation or at a lower elevation during the test.

I. No backfill shall be placed against the walls or on the wall footings of the structure to be tested unless otherwise specified.

3.02 PROCEDURE

A. The initial filling of a new structure should not exceed a rate of 4 ft/h. Filling shall be continued until the water surface is at the design maximum liquid level, or either 1 in. below any fixed overflow level in covered containment structure or 4 in. in open structure, whichever is lower.

B. The exterior surfaces of the structure shall be inspected during the period of filling the structure. If any flow of water is observed from the structure exterior surfaces, including joints or cracks, the defect causing the leakage shall be repaired prior to testing.

C. Watertightness Test - Part 1: Qualitative Criteria

1. The water shall be kept at the test level for at least 3 days prior to Part 2 of the testing.

2. The exterior surfaces of the structure shall be observed in both the early mornings and later afternoons during the 3-day period before Part 2 of the test. If any water is observed on the structure exterior surfaces, including joints, repaired honeycombed areas and cracks, where moisture can be picked up on a dry hand, the containment structure shall be considered to have failed Part 1 of the test.

3. Wet areas on top of wall footing shall not be cause to fail Part 1 of the test unless the water can be observed to be flowing.

4. Part 2 of the test may begin prior to completion of repairs for Part 1. However, all defects causing the failure of Part 1 shall be repaired before the structure is accepted.

D. Watertightness Test - Part 2: Quantitative Criteria

1. The test measurements shall not be scheduled for a period when the forecast is for a difference of more than 35°F between the ambient temperature readings at the times of the initial and final level measurements of the water surface. The test shall also not be scheduled when the weather forecast indicates the water surface would be frozen before the test is completed.

2. The vertical distance to the water surface shall be measured to within 1/16 in. from a fixed point on the structure above the water surface. Measurements shall be recorded at 24-hour intervals. Measurements taken at the same time of day will reduce the probability of temperature difference.

3. Measurements shall be taken at two locations, 180° apart, which will minimize the effect of differential settlement. Measurements shall be taken at the same locations to reduce the probability of measurement differences.

4. The test period shall be at least the theoretical time required to lower the water surface 3/8 in. assuming a loss of water at 0.050% of the water volume per 24-hour period. The test period shall not be longer than five days.

5. The water temperature shall be recorded at a depth of 18 in. below the water surface at the start and end of the test.

6. A floating, restrained, partially filled, calibrated, open container for evaporation and precipitation measurement should be positioned in open structures and the water level in the container recorded at 24-hour intervals. Determination of evaporation by a shallow pan-type measuring device is not acceptable due to possible heating of the bottom of the shallow pan resulting in accelerated evaporation.

3.03 EVALUATION

A. The containment structure shall continue to be observed in both the early mornings and late afternoons to verify compliance with Part 1 of the test during Part 2.

B. At the end of the test period, the water surface shall be recorded to within 1/16-in at the location of original measurements. The water temperature and the evaporation and precipitation measurements shall be recorded.

C. The allowable loss of water for tightness tests shall not exceed 0.050% of the test water volume in 24 hours.

D. The change in water volume in the structure shall be calculated and corrected, if necessary, for evaporation, precipitation, and temperature based on the change recorded in the water level from the open container. If the loss exceeds the allowable loss, the structure shall be considered to have failed the test.

E. During Part 2 of the test, observed flow or seepage of water from the exterior surface, including that from cracks and joints, should be considered as a failed test. The structure shall also be considered to have failed the test if moisture can be transferred from the exterior surface to a dry hand. Dampness or wetness on top of a footing shall not be considered as a failure test.

3.04 RETESTING

A. A restart of the test shall be required when test measurements become unreliable due to unusual precipitation or other external factors.

B. The Contractor shall be permitted to immediately retest when no visible leakage is exhibited. If the structure fails the second test or if the Contractor does not exercise the option of immediately retesting after the first test failure, the interior of the structure shall be inspected by a diver or by other means to determine probable areas of leakage. The structure shall only be retested after the most probable areas of leakage are repaired.

C. If the leakage exceeds the allowable limit, the work shall be corrected by methods approved by the Engineer.

D. Upon completion of the necessary remedial work, the leakage test shall be repeated until it is successfully passed.

3.05 NOTIFICATION BY ENGINEER

A. If any leaks, in excess of the specified amount, are not remedied by the Contractor within four (4) weeks of notification by the Engineer, regardless of whether the cause of these leaks is or is not determined, the Engineer shall have the authority to have these leaks repaired by others. The cost of repairs, by others, shall be deducted from monies due or to become due to the General Contractor.

- END OF SECTION -

SECTION 01510

TEMPORARY UTILITIES

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall provide temporary utilities including, but not limited to, electrical, heating, water service, and sanitary facilities. The temporary services shall be provided for use throughout the construction period.

B. The Contractor shall coordinate and install all temporary services in accordance with the requirements of the utility companies having jurisdiction and as required by applicable codes and regulations.

C. At the completion of the work, or when the temporary services are no longer required, the facilities shall be restored to their original conditions.

D. All costs in connection with the temporary services including, but not limited to, installation, utility company service charges, maintenance, relocation and removal shall be borne by the Contractor at no additional cost to the Owner.

PART 2 -- PRODUCTS

(NOT USED)

PART 3 -- EXECUTION

(NOT USED)

- END OF SECTION -

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SECTION 01530

PROTECTION OF EXISTING FACILITIES

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Contractor shall be responsible for the preservation and protection of property adjacent to the work site against damage or injury as a result of his operations under this Contract. Any damage or injury occurring on account of any act, omission or neglect on the part of the Contractor shall be restored in a proper and satisfactory manner or replaced by and at the expense of the Contractor to an equal or superior condition than previously existed.

B. Contractor shall comply promptly with such safety regulations as may be prescribed by the Owner or the local authorities having jurisdiction and shall, when so directed, properly correct any unsafe conditions created by, or unsafe practices on the part of, his employees. In the event of the Contractor's failure to comply, the Owner may take the necessary measures to correct the conditions or practices complained of, and all costs thereof will be deducted from any monies due the Contractor. Failure of the Engineer to direct the correction of unsafe conditions or practices shall not relieve the Contractor of his responsibility hereunder.

C. In the event of any claims for damage or alleged damage to property as a result of work under this Contract, the Contractor shall be responsible for all costs in connection with the settlement of or defense against such claims. Prior to commencement of work in the vicinity of property adjacent to the work site, the Contractor, at his own expense, shall take such surveys as may be necessary to establish the existing condition of the property. Before final payment can be made, the Contractor shall furnish satisfactory evidence that all claims for damage have been legally settled or sufficient funds to cover such claims have been placed in escrow, or that an adequate bond to cover such claims has been obtained.

1.02 PROTECTION OF WORK AND MATERIAL

A. During the progress of the work and up to the date of final payment, the Contractor shall be solely responsible for the care and protection of all work and materials covered by the Contract.

B. All work and materials shall be protected against damage, injury or loss from any cause whatsoever, and the Contractor shall make good any such damage or loss at his own expense. Protection measures shall be subject to the approval of the Engineer.

1.03 BARRICADES, WARNING SIGNS AND LIGHTS

A. The Contractor shall provide, erect and maintain as necessary, strong and suitable barricades, danger signs and warning lights along all roads accessible to the public, as required by the authority having jurisdiction, to insure safety to the public. All barricades

and obstructions along public roads shall be illuminated at night and all lights for this purpose shall be kept burning from sunset to sunrise.

B. The Contractor shall provide and maintain such other warning signs and barricades in areas of and around their respective work as may be required for the safety of all those employed in the work, the Owner's operating personnel, or those visiting the site.

1.04 EXISTING UTILITIES AND STRUCTURES

A. The term existing utilities shall be deemed to refer to both publicly-owned and privately-owned utilities such as electric power and lighting, telephone, water, gas, storm drains, process lines, sanitary sewers and all appurtenant structures.

B. Where existing utilities and structures are indicated on the Drawings, it shall be understood that all of the existing utilities and structures affecting the work may not be shown and that the locations of those shown are approximate only. It shall be the responsibility of the Contractor to ascertain the actual extent and exact location of existing utilities and structures. In every instance, the Contractor shall notify the proper authority having jurisdiction and obtain all necessary directions and approvals before performing any work in the vicinity of existing utilities.

C. Prior to beginning any excavation work, the Contractor shall, through field investigations, determine any conflicts or interferences between existing utilities and new utilities to be constructed under this project. This determination shall be based on the actual locations, elevations, slopes, etc., of existing utilities as determined in the field investigations, and locations, elevation, slope, etc. of new utilities as shown on the Drawings. If an interference exists, the Contractor shall bring it to the attention of the Engineer as soon as possible. If the Engineer agrees that an interference exists, he shall modify the design as required. Additional costs to the Contractor for this change shall be processed through a Change Order as detailed elsewhere in these Contract Documents. In the event the Contractor fails to bring a potential conflict or interference to the attention of the Engineer prior to beginning excavation work, any actual conflict or interference which does arise during the Project shall be corrected by the Contractor, as directed by the Engineer, at no additional expense to the Owner.

D. The work shall be carried out in a manner to prevent disruption of existing services and to avoid damage to the existing utilities. Temporary connections shall be provided, as required, to insure uninterruption of existing services. Any damage resulting from the work of this Contract shall be promptly repaired by the Contractor at his own expense in a manner approved by the Engineer and further subject to the requirements of any authority having jurisdiction. Where it is required by the authority having jurisdiction that they perform their own repairs or have them done by others, the Contractor shall be responsible for all costs thereof.

E. Where excavations by the Contractor require any utility lines or appurtenant structures to be temporarily supported and otherwise protected during the construction work, such support and protection shall be provided by the Contractor. All such work shall be performed in a manner satisfactory to the Engineer and the respective authority having jurisdiction over such work. In the event the Contractor fails to provide proper support or protection to any

existing utility, the Engineer may, at his discretion, have the respective authority to provide such support or protection as may be necessary to insure the safety of such utility, and the costs of such measures shall be paid by the Contractor.

F. The existing pump station will be maintained in continuous operation by the Owner during the entire construction period

G. Work under this Contract shall be scheduled and conducted by the Contractor so as not to impede the Owner from accessing, maintaining, and operating the existing pump station.

H. Should the Owner's ability to access, maintain, or operate the existing pump station, the Contractor shall be responsible for all operations and maintenance during the interruption at no additional cost to the Owner.

1.05 SPECIFIC OPERATIONAL CONSTRAINTS

A. The Contractor shall schedule the work for the following based on the constraints given in such a manner as to maintain the existing pump station in continuous operation.

1. A proposed sequence for constructing the gravity sewer, minimizing bypass pumping, is provided on drawing .

2. The Contractor may propose an alternate sequence; however, all necessary bypass pumping shall be supplied by the contractor to convey the incoming wastewater to the existing pump station or force main.

PART 2 -- PRODUCTS

(NOT USED)

PART 3 -- EXECUTION

(NOT USED)

- END OF SECTION -

SECTION 01540

DEMOLITION AND REMOVAL OF EXISTING STRUCTURES AND EQUIPMENT

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. This Section covers the demolition, removal, and disposal of existing buildings, structures, concrete and asphalt pavement, curbs, and sidewalk, removal and disposal of asbestos materials, miscellaneous yard structures, and any existing equipment including electrical, plumbing, heating and ventilating equipment and piping not required for the operation of the existing pump station as indicated on the Drawings and as specified hereinafter. The Contractor shall furnish all labor, materials and equipment to demolish buildings and structures and to remove fixtures, anchors, supports, piping and accessories designated to be removed on the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 01090 - Reference Standards

B. Section 01530 – Protection of Existing Facilities

1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. References shall be in accordance with reference standards, codes, and specifications as set forth herein and in Section 02100 - Clearing, Grubbing, and Site Preparation.

1.04 TITLE TO EQUIPMENT AND MATERIALS

A. Contractor shall have no right or title to any of the equipment, materials or other items to be removed from the existing buildings or structures unless and until said equipment, materials and other items have been removed from the premises. The Contractor shall not sell or assign, or attempt to sell or assign any interest in the said equipment, materials or other items until the said equipment, materials or other items have been removed.

B. Contractor shall have no claim against the Owner because of the absence of such fixtures and materials.

1.05 CONDITION OF STRUCTURES AND EQUIPMENT

A. The Owner does not assume responsibility for the actual condition of structures and equipment to be demolished and removed.

B. Conditions existing at the time of inspection for bidding purposes will be maintained by the Owner so far as practicable.

C. The information regarding the existing structures and equipment shown on the Drawings is based on visual inspection and a walk-through survey only. Neither the Engineer nor the Owner will be responsible for interpretations or conclusions drawn therefrom by the Contractor.

PART 2 -- PRODUCTS

2.01 FILL MATERIALS

A. Fill materials shall be as defined under Section 02200, Earthwork.

PART 3 -- EXECUTION

3.01 DEMOLITION AND REMOVALS

A. The removal of all equipment and piping, and all materials from the demolition of buildings and structure shall, when released by the Owner and Engineer, be performed by the Contractor and shall become the Contractor's property, unless otherwise noted, for disposition in any manner not contrary to the Contract requirements and shall be removed from the site to the Contractor's own place of disposal.

B. The Electrical Contractor (Subcontractor) specifically, shall de-energize all panelboards, lighting fixtures, switches, circuit breakers, electrical conduits, motors, limit switches, pressure switches, instrumentation such as flow, level and/or other meters, wiring, and similar power equipments prior to removal. Any electric panels or equipment which are to be retained shall be relocated or isolated by the Electrical Contractor (Subcontractor) specifically, prior to the removal of the equipment specified herein.

C. The Contractor shall proceed with the removal of the equipment, piping and appurtenances in a sequence designed to maintain the existing pump station in continuous operation as described in Section 01530, Protection of Existing Facilities, and shall proceed only after approval of the Engineer.

D. Any equipment piping and appurtenances removed without proper authorization, which are necessary for the operation of the existing facilities shall be replaced to the satisfaction of the Engineer at no cost to the Owner.

E. Excavation caused by demolitions shall be backfilled with fill free from rubbish and debris.

F. Work shall be performed in such manner as not to endanger the safety of the workmen or the public or cause damage to nearby structures.

G. Provide all barriers and precautionary measures in accordance with Owner's requirements and other authorities having jurisdiction.

H. Where parts of existing structures are to remain in service, demolish the portions to be removed, repair damage, and leave the structure in proper condition for the intended use. Remove concrete and masonry to the lines designated by drilling, chipping, or other suitable methods. Leave the resulting surfaces reasonably true and even, with sharp straight corners that will result in neat joints with new construction and be satisfactory for the

purpose intended. Where existing reinforcing rods are to extend into new construction, remove the concrete so that the reinforcing is clean and undamaged. Cut off other reinforcing 1/2-inch below the surface and fill with epoxy resin binder flush with the surface.

I. Prior to the execution of the work, the Contractor, Owner and Engineer shall jointly survey the condition of the adjoining and/or nearby structures. Photographs and records shall be made of any prior settlement or cracking of structures, pavements, and the like, that may become the subject of possible damage claims.

3.02 DISPOSAL OF MATERIAL

A. All debris resulting from the demolition and removal work shall be disposed of by the Contractor as part of the work of this Contract. Material designated by the Engineer to be salvaged shall be stored on the construction site as directed. All other material shall be disposed of offsite by the Contractor at his expense.

B. Burning of any debris resulting from the demolition will not be permitted at the site.

3.03 PROTECTION

A. Demolition and removal work shall be performed by competent experienced workmen for the various type of demolition and removal work and shall be carried out through to completion with due regard to the safety of Owner employees, workmen on-site and the public. The work shall be performed with as little nuisance as possible.

B. The work shall comply with the applicable provisions and recommendation of ANSI A10.2, Safety Code for Building Construction, all governing codes, and as hereinafter specified.

C. The Contractor shall make such investigations, explorations and probes as are necessary to ascertain any required protective measures before proceeding with demolition and removal. The Contractor shall give particular attention to shoring and bracing requirements so as to prevent any damage to new or existing construction.

D. The Contractor shall provide, erect, and maintain catch platforms, lights, barriers, weather protection, warning signs and other items as required for proper protection of the public, occupants of the building, workmen engaged in demolition operations, and adjacent construction.

E. The Contractor shall provide and maintain weather protection at exterior openings so as to fully protect the interior premises against damage from the elements until such openings are closed by new construction.

F. The Contractor shall provide and maintain temporary protection of the existing structure designated to remain where demolition, removal and new work is being done, connections made, materials handled or equipment moved.

G. The Contractor shall take necessary precautions to prevent dust from rising by wetting demolished masonry, concrete, plaster and similar debris. Unaltered portions of the existing buildings affected by the operations under this Section shall be protected by dust-proof partitions and other adequate means.

H. The Contractor shall provide adequate fire protection in accordance with local Fire Department requirements.

I. The Contractor shall not close or obstruct walkways, passageways, or stairways and shall not store or place materials in passageways, stairs or other means of egress. The Contractor shall conduct operations with minimum traffic interference.

J. The Contractor shall be responsible for any damage to the existing structure or contents by reason of the insufficiency of protection provided.

3.04 WORKMANSHIP

A. The demolition and removal work shall be performed as described in the Contract Documents. The work required shall be done with care, and shall include all required shoring, bracing, etc. The Contractor shall be responsible for any damage which may be caused by demolition and removal work to any part or parts of existing structures or items designated for reuse or to remain. The Contractor shall perform patching, restoration and new work in accordance with applicable Technical Sections of the Specifications and in accordance with the details shown on the Drawings. Prior to starting of work, the Contractor shall provide a detailed description of methods and equipment to be used for each operation and the sequence thereof for review by the Engineer.

B. All supports, pedestals and anchors shall be removed with the equipment and piping unless otherwise specified or required. Concrete bases, anchor bolts and other supports shall be removed to approximately 1-inch below the surrounding finished area and the recesses shall be patched to match the adjacent areas. Superstructure wall and roof openings shall be closed, and damaged surfaces shall be patched to match the adjacent areas, as specified under applicable Sections of these Specifications, as shown on the Drawings, or as directed by the Engineer. Wall sleeves and castings shall be plugged or blanked off, all openings in concrete shall be closed in a manner meeting the requirements of the appropriate Sections of these Specifications, as shown on the Drawings, and as directed and approved by the Engineer.

C. Materials or items designated to remain the property of the Owner shall be as hereinafter tabulated. Such items shall be removed with care and stored at a location at the site to be designated by the Owner.

D. Where equipment is shown or specified to be removed and relocated, the Contractor shall not proceed with removal of this equipment without specific prior approval of the Engineer. Upon approval, and prior to commencing removal operations, the equipment shall be operated in the presence of representatives of the Contractor, Owner and Engineer. Such items shall be removed with care, under the supervision of the trade responsible for reinstallation and protected and stored until required. Material or items damaged during removal shall be replaced with similar new material or item. Any equipment that is removed without proper authorization and is required for the existing pump station operation shall be replaced at no cost to the Owner.

E. Wherever piping is to be removed for disposition, the piping shall be drained by the Contractor and adjacent pipe and headers that are to remain in service shall be blanked off or plugged and then anchored in an approved manner.

F. Materials or items demolished and not designated to become the property of the Owner or to be reinstalled shall become the property of the Contractor and shall be removed from the property and legally disposed of.

G. The Contractor shall execute the work in a careful and orderly manner, with the least possible disturbance to the public and to the occupants of the building.

H. In general, masonry shall be demolished in small sections, and where necessary to prevent collapse of any construction, the Contractor shall install temporary shores, struts, and bracing.

I. Where alterations occur, or new and old work join, the Contractor shall cut, remove, patch, repair or refinish the adjacent surfaces to the extent required by the construction conditions, so as to leave the altered work in as good a condition as existed prior to the start of the work. The materials and workmanship employed in the alterations, unless otherwise shown on the Drawing or specified, shall comply with that of the various respective trades which normally perform the particular items or work.

J. The Contractor shall finish adjacent existing surfaces to new work to match the specified finish for new work. The Contractor shall clean existing surfaces of dirt, grease, loose paint, etc., before refinishing.

K. The Contractor shall cut out embedded anchorage and attachment items as required to properly provide for patching and repair of the respective finishes.

L. The Contractor shall confine cutting of existing roof areas designated to remain to the limits required for the proper installation of the new work. The Contractor shall cut and remove insulation, etc., and provide temporary weather tight protection as required until new roofing and flashings are installed.

M. The Contractor shall remove temporary work, such as enclosures, signs, guards, and the like when such temporary work is no longer required or when directed at the completion of the work.

3.05 MAINTENANCE

A. The Contractor shall maintain the buildings, structures and public properties free from accumulations of waste, debris and rubbish, caused by the demolition and removal operations.

B. The Contractor shall provide on-site dump containers for collection of waste materials, debris and rubbish, and he shall wet down dry materials to lay down and prevent blowing dust.

C. At reasonable intervals during the progress of the demolition and removal work or as directed by the Engineer, the Contractor shall clean the site and properties, and dispose of waste materials, debris and rubbish.

3.06 EQUIPMENT AND MATERIALS RETAINED BY OWNER

A. The following equipment and materials will be retained by the Owner:

COORDINATE WITH BCWS

B. The equipment and materials shall be moved by the Contractor to storage areas, on the site, to be designated by the Owner.

- END OF SECTION -

SECTION 01550

SITE ACCESS AND STORAGE

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Access Roads

1. The Contractor shall construct and maintain such temporary access roads as required to perform the work of this Contract.

2. Access roads, where possible, shall be located over the areas of the future road system.

3. Access roads shall be located within the property lines of the Owner unless the Contractor independently secures easements for his use and convenience. Contractor shall submit written documentation to the Engineer for any Contractor secured easements across privately held property. Easement agreement shall specify terms and conditions of use and provisions for site restoration. A written release from the property owner certifying that all terms of the easement agreement have been complied by the Contractor shall be furnished to the Engineer prior to final payment.

4. Existing access roads used by the Contractor shall be suitably maintained by the Contractor at his expense during construction. Contractor shall not be permitted to restrict Owner access to existing facilities. Engineer may direct Contractor to perform maintenance of existing access roads when Engineer determines that such work is required to insure all weather access by the Owner.

5. The Contractor shall obtain and pay all cost associated with any bonds required by the South Carolina Department of Transportation for the use of State maintained roads.

B. Parking Areas

1. The Contractor shall construct and maintain suitable parking areas for his construction personnel on the project site where approved by the Engineer and the Owner.

C. Restoration

1. At the completion of the work, the surfaces of land used for access roads and parking areas shall be restored by each Contractor to its original condition and to the satisfaction of the Engineer. At a minimum, such restoration shall include establishment of a permanent ground cover adequate to restrain erosion for all disturbed areas.

D. Traffic Regulations

1. Contractor shall obey all traffic laws and comply with all the requirements, rules and regulations of the South Carolina Department of Transportation and other local authorities having jurisdiction to maintain adequate warning signs, lights, barriers, etc., for the protection of traffic on public roadways.

E. Storage of Equipment and Materials

1. Contractor shall store his equipment and materials at the job site in accordance with the requirements of the General Conditions, the Supplemental Conditions, and as hereinafter specified. All equipment and materials shall be stored in accordance with manufacturer's recommendations and as directed by the Owner or Engineer, and in conformity to applicable statutes, ordinances, regulations and rulings of the public authority having jurisdiction. Where space or strip heaters are provided within the enclosure for motors, valve operators, motor starters, panels, instruments, or other electrical equipment, the Contractor shall make connections to these heaters from an appropriate power source and operate the heaters with temperature control as necessary until the equipment is installed and being operated according to its intended use.

2. Contractor shall enforce the instructions of Owner and Engineer regarding the posting of regulatory signs for loadings on structures, fire safety, and smoking areas.

3. Contractor shall not store materials or encroach upon private property without the written consent of the owners of such private property.

4. Contractor shall not store unnecessary materials or equipment on the job site, and shall take care to prevent any structure from being loaded with a weight which will endanger its security or the safety of persons.

5. Materials shall not be placed within ten (10) feet of fire hydrants. Gutters, drainage channels and inlets shall be kept unobstructed at all times.

6. Contractor shall provide adequate temporary storage buildings/facilities, if required, to protect materials or equipment on the job site.

## PART 2 -- PRODUCTS

(NOT USED)

## PART 3 -- EXECUTION

(NOT USED)

- END OF SECTION -

SECTION 01560

TEMPORARY ENVIRONMENTAL CONTROLS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Dust Control

1. Contractor shall take all necessary measures to control dust from his operations, and to prevent spillage of excavated materials on public roads.

2. Contractor shall remove all spillage of excavated materials, debris or dust from public roads by methods approved by the Engineer.

3. Contractor shall sprinkle water at locations and in such quantities and at such frequencies as may be required by the Engineer to control dust and prevent it from becoming a nuisance to the surrounding area.

4. Dust control and cleaning measures shall be provided at no additional cost to the Owner.

PART 2 -- PRODUCTS

(NOT USED)

PART 3 -- EXECUTION

(NOT USED)

- END OF SECTION -

SECTION 01600

MATERIALS AND EQUIPMENT

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Furnish and Install

1. Where the words "furnish", "provide", "supply", "replace", or "install" are used, whether singularly or in combination, they shall mean to furnish and install, unless specifically stated otherwise.

2. In the interest of brevity, the explicit direction "to furnish and install" has sometimes been omitted in specifying materials and/or equipment herein. Unless specifically noted otherwise, it shall be understood that all equipment and/or materials specified or shown on the Drawings shall be furnished and installed under the Contract as designated on the Drawings.

B. Concrete Foundations for Equipment

1. The Contractor shall provide all concrete foundations shown, specified or required for all equipment furnished under their respective Contract.

2. Anchor bolts and templates for equipment foundations shall be furnished under the Contract for installation by the Contractor. The Contractor shall cooperate with the subcontractors to secure a satisfactory installation and to maintain the schedule of construction.

1.02 EQUIPMENT AND MATERIALS

A. All equipment, materials, instruments or devices incorporated in this project shall be new and unused, unless indicated otherwise in the Contract Documents. Equipment and materials to be incorporated into the work shall be delivered sufficiently in advance of their installation and use to prevent delay in the execution of the work, and they shall be delivered as nearly as feasible in the order required for executing the work.

B. The Contractor shall protect all equipment and materials from deterioration and damage, including provisions for temporary storage buildings as needed and as specified in Section 01550, Site Access and Storage. Storage of equipment and materials shall be in locations completely protected from flooding, standing water, excessive dust, falling rock, brush fire, etc. Storage areas shall be located sufficiently distant from all construction activities and the movement of construction vehicles to minimize the potential for accidental damage. Any equipment or materials of whatever kind which may have become damaged or deteriorated from any cause shall be removed and replaced by good and satisfactory items at the Contractor's expense for both labor and materials.

1.03 INSTALLATION OF EQUIPMENT

A. Equipment and materials shall be installed in accordance with the requirements of the General Conditions, Supplemental Conditions and the respective Specification Sections.

B. Concrete foundations for equipment shall be of approved design and shall be adequate in size, suitable for the equipment erected thereon and properly reinforced. Foundation bolts of ample size and strength shall be provided and properly positioned by means of suitable templates and secured during placement of concrete. Foundations shall be built and bolts installed in accordance with the manufacturer's certified drawings.

1.04 CONNECTIONS TO EQUIPMENT

A. Connections to equipment shall follow manufacturer's recommendations as to size and arrangement of connections and/or as shown in detail on the Drawings or approved Shop Drawings. Piping connections shall be made to permit ready disconnection of equipment with minimum disturbance of adjoining piping and equipment.

B. The Contractor shall be responsible for bringing proper electrical service to each item of equipment requiring electrical service as shown on the Drawings or approved Shop Drawings. Electrical connections to equipment requiring electrical service shall be made by the Contractor, unless otherwise indicated on the Drawings or Specifications.

1.05 SUBSTITUTIONS

A. Requests for substitutions of equipment or materials shall conform to the requirements of the General Conditions, Supplemental Conditions, and as hereinafter specified.

1. Contractor shall submit for each proposed substitution sufficient details, complete descriptive literature and performance data together with samples of the materials, where feasible, to enable the Owner and Engineer to determine if the proposed substitution is equal.

2. Contractor shall submit certified tests, where applicable, by an independent laboratory attesting that the proposed substitution is equal.

3. A list of installations where the proposed substitution is equal.

4. Requests for substitutions shall include full information concerning differences in cost, and any savings in cost resulting from such substitutions shall be passed on to the Owner.

B. Where the approval of a substitution requires revision or redesign of any part of the work, all such revision and redesign, and all new drawings and details therefore, shall be provided by the Contractor at his own cost and expense, and shall be subject to the approval of the Owner and Engineer.

C. In the event that the Engineer is required to provide additional engineering services, then the Engineer's charges for such additional services shall be charged to the Contractor by the Owner in accordance with the requirements of the General Conditions, and the Supplemental Conditions.

D. In all cases the Owner and Engineer shall be the judge as to whether a proposed substitution is to be approved. The Contractor shall abide by their decision when proposed substitute items are judged to be unacceptable and shall in such instances furnish the item specified or indicated. No substitute items shall be used in the work without written approval of the Owner and Engineer.

E. Contractor shall have and make no claim for an extension of time or for damages by reason of the time taken by the Engineer in considering a substitution proposed by the Contractor or by reason of the failure of the Engineer to approve a substitution proposed by the Contractor.

F. Acceptance of any proposed substitution shall in no way release the Contractor from any of the provisions of the Contract Documents.

PART 2 -- PRODUCTS

(NOT USED)

PART 3 -- EXECUTION

(NOT USED)

- END OF SECTION -

SECTION 01700

PROJECT CLOSEOUT

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Final Cleaning

1. At the completion of the work, the Contractor shall remove all rubbish from and about the site of the work, and all temporary structures, construction signs, tools, scaffolding, materials, supplies and equipment which may have used in the performance of the work. Contractor shall broom clean paved surfaces and rake clean other surfaces of grounds.

2. Contractor shall thoroughly clean all materials, equipment and structures; all marred surfaces shall be touched up to match adjacent surfaces.

3. Contractor shall maintain cleaning until project is occupied by the Owner.

B. Equipment Start-Up Services

1. Contractor shall notify Owner and Engineer fourteen (14) days prior to system start-up.

a. Provide a written schedule of start-up activities including but not limited to the reconnection of electrical power, water piping, and sewer piping.

b. Coordinate preparation of this schedule with the Engineer and the Owner.

2. Equipment start-up period, for the training of Owner personnel, shall begin after satisfactory completion and acceptance of the field tests and coincide with the certified date of substantial completion for the part of the work for which the equipment is included. If the equipment is not covered by a certificate of substantial completion for a part of the work, the period shall begin upon substantial completion of the project.

3. During the equipment start-up period the Contractor shall furnish, at no additional cost to the Owner, the services of factory trained representatives of the equipment manufacturers for the equipment designated in the Specifications to:

a. Assist in the start-up and operations of the equipment.

b. Assist in the training of personnel designated by the Owner in the proper operation and maintenance of the equipment.

4. The Owner shall:

   a. Provide the necessary personnel to be instructed in the operation and maintenance of the equipment. The Owner's personnel shall operate all equipment.

   b. Pay for all fuel, power, and chemicals consumed beyond quantities specified in the Contract Documents. The Contractor shall pay for fuel, power, and chemicals consumed up to the date of "certified substantial completion" except as otherwise specified herein.

5. Contractor shall be available to promptly repair all work during the start-up period so as to cause minimum disruption to the operation of the pump station.

6. Upon completion of satisfactory operation and receipt of the Permit to Operate from South Carolina Department of Health and Environmental Control, the Owner will assume operation and operating cost of the equipment. If the equipment malfunctions during this start-up period, the start-up period will be repeated until satisfactory operation is achieved.

7. In the event a system, equipment or component proves defective or is unable to meet specified performance criteria, the Contractor shall replace the defective item and the minimum guarantee period called for in the Specifications shall start after satisfactory replacement and testing of the item.

C. Final Cleanup; Site Rehabilitation

1. The Contractor shall wash and clean all exposed surfaces which have become soiled or marked, and shall remove from the site of work all accumulated debris and surplus materials of any kind which result from his operation, including construction equipment, tools, sheds, sanitary enclosures, etc. The Contractor shall leave all equipment, fixtures, and work, which he has installed, in a clean condition. The completed project shall be turned over to the Owner in a neat and orderly condition.

2. The site of the work shall be rehabilitated or developed in accordance with other sections of the Specifications and the Drawings. In the absence of any portion of these requirements, the Contractor shall completely rehabilitate the site to a condition and appearance equal or superior to that which existed just prior to construction, except for those items whose permanent removal or relocation was required in the Contract Documents or ordered by the Owner.

D. Final Inspection

1. Final cleaning and repairing shall be so arranged as to be finished upon completion of the construction work. Any portion of the work inspected and accepted by the Engineer shall be kept clean by the Contractor until the final acceptance of the entire work.

2. The Contractor, upon completion of final cleaning and repairing, shall notify the Engineer for final inspection of the whole or a portion of the work, and the Engineer will thereupon inspect the work. If the work is not found satisfactory, the Engineer will order further cleaning, repairs, or replacement.

3. When such further cleaning or repairing is completed, the Engineer, upon further notice, will again inspect the work. The "Final Payment" will not be processed until the Contractor has complied with the requirements set forth, and the Engineer has made his final inspection of the entire work and is satisfied that the entire work is properly and satisfactorily constructed in accordance with the requirements of the Contract Documents.

E. Project Close Out

1. As construction of the project enters the final stages of completion, the Contractor shall, in concert with accomplishing the requirements set forth in the Contract Documents, attend to or have already completed the following items as they apply to his contract:

   a. Scheduling equipment manufacturers' visits to site.

   b. Required testing of project components.

   c. Scheduling start-up and initial operation.

   d. Scheduling and furnishing skilled personnel during initial operation.

   e. Correcting or replacing defective work, including completion of items previously overlooked or work which remains incomplete, all as evidenced by the Engineer's "Punch" Lists.

   f. Attend to any other items listed herein or brought to the Contractor's attention by the Engineer.

2. Just before the Engineer's Certificate of Substantial Completion is issued, the Contractor shall accomplish the cleaning and final adjustment of the various building components as specified in the Specifications and as follows:

   a. Clean all finish hardware after adjustment for proper operation.

   b. Touch up marks or defects in painted surfaces and touch up any similar defects in factory finished surfaces.

   c. Remove all stains, marks, fingerprints, soil, spots, and blemishes from all finished surfaces.

3. In addition, and before the Certificate of Substantial Completion is issued, the Contractor shall submit to the Engineer (or to the Owner if indicated) certain records, certifications, etc., which are specified elsewhere in the Contract Documents. A

partial list of such items appears below, but it shall be the Contractor's responsibility to submit any other items which are required in the Contract Documents:

a. Test results of project components.

b. Performance Affidavits for equipment.

c. Certification of equipment or materials in compliance with Contract Documents.

d. Operation and maintenance instructions or manuals for equipment.

e. One set of neatly marked-up record documents accurately showing as-built changes and additions to the work under his Contract.

f. Any special guarantees or bonds (Submit to Owner).

4. The Contractor's attention is directed to the fact that required certifications and information under Item 3 above, must actually be submitted earlier in accordance with other Sections of the Specifications.

PART 2 -- PRODUCTS

(NOT USED)

PART 3 -- EXECUTION

(NOT USED)

- END OF SECTION -

SECTION 02100

CLEARING, GRUBBING, AND SITE PREPARATION

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Includes all labor, material, equipment and appliances required for the complete execution of any additions, modifications, or alterations to existing building(s) and new construction work as shown on the Drawings and specified herein.

B. Principal items of work include:

1. Notifying all authorities owning utility lines running to or on the property. Protecting and maintaining all utility lines to remain and capping those that are not required in accordance with instructions of the Utility Companies, and all other authorities having jurisdiction.

2. Clearing the site within the Contract Limit Lines, including removal of grass, brush, shrubs, trees, loose debris and other encumbrances except for trees marked to remain.

3. Boxing and protecting all trees, shrubs, lawns and the like within areas to be preserved. Relocating trees and shrubs, so indicated on the Drawings, to designated areas.

4. Repairing all injury to trees, shrubs, and other plants caused by site preparation operations shall be repaired immediately. Work shall be done by qualified personnel in accordance with standard horticultural practice and as approved by the Engineer.

5. Removing topsoil to its full depth from designated areas and stockpiling on site where directed by the Engineer for future use.

6. Disposing from the site all debris resulting from work under this Section.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 02200 – Earthwork

B. Section 02276 – Erosion and Sedimentation Control

1.03 STREET AND ROAD BLOCKAGE

A. Closing of streets and roads during progress of the work shall be in compliance with the requirements of the Owner and other authorities having jurisdiction. Access shall be provided to all facilities remaining in operation.

1.04 PROTECTION OF PERSONS AND PROPERTY

A. All work shall be performed in such a manner to protect all personnel, workmen, pedestrians and adjacent property and structures from possible injury and damage.

B. All conduits, wires, cables and appurtenances above or below ground shall be protected from damage.

C. Provide warning and barrier fence where shown on the Drawings and as specified herein.

PART 2 -- EXECUTION

2.01 CLEARING OF SITE

A. Before removal of topsoil, and start of excavation and grading operations, the areas within the clearing limits shall be cleared and grubbed.

B. Clearing shall consist of cutting, removal, and satisfactory disposal of all trees, fallen timber, brush, bushes, rubbish, sanitary landfill material, fencing, and other perishable and objectionable material within the areas to be excavated or other designated areas. Prior to the start of construction, the Contractor shall survey the entire Contract site and shall prepare a plan which defines the areas to be cleared and grubbed, trees to be pruned, extent of tree pruning, and/or areas which are to be cleared but not grubbed. This plan shall be submitted to the Engineer for approval. Should it become necessary to remove a tree, bush, brush or other plants adjacent to the area to be excavated, the Contractor shall do so only after permission has been granted by the Engineer.

C. Excavation resulting from the removal of trees, roots and the like shall be filled with suitable material, as approved by the Engineer, and thoroughly compacted per the requirements contained in Section 02200, Earthwork.

D. Unless otherwise shown or specified, the Contractor shall clear and grub a strip at least 15 ft. wide along all permanent fence lines installed under this Contract.

E. In temporary construction easement locations, only those trees and shrubs shall be removed which are in actual interference with excavation or grading work under this Contract, and removal shall be subject to approval by the Engineer. However, the Engineer reserves the right to order additional trees and shrubs removed at no additional cost to the Owner, if such, in his opinion, are too close to the work to be maintained or have become damaged due to the Contractor's operations.

2.02 STRIPPING AND STOCKPILING EXISTING TOPSOIL

A. Existing topsoil and sod on the site within areas designated on the Drawings shall be stripped to whatever depth it may occur, and stored in locations directed by the Engineer.

B. The topsoil shall be free of stones, roots, brush, rubbish, or other unsuitable materials before stockpiling the topsoil.

C. Care shall be taken not to contaminate the stockpiled topsoil with any unsuitable materials.

2.03 GRUBBING

A. Grubbing shall consist of the removal and disposal of all stumps, roots, logs, sticks and other perishable materials to a depth of at least 6-inches below ground surfaces.

B. Large stumps located in areas to be excavated may be removed during grading operations, subject to the approval of the Engineer.

2.04 DISPOSAL OF MATERIAL

A. All debris resulting from the clearing and grubbing work shall be disposed of by the Contractor as part of the work of this Contract. Material designated by the Engineer to be salvaged shall be stored on the construction site as directed by the Engineer for reuse in this Project or removal by others.

B. Burning of any debris resulting from the clearing and grubbing work will not be permitted at the site.

2.05 WARNING AND BARRIER FENCE

A. The fence shall be made of a visible, lightweight, flexible, high strength polyethylene material. The fence shall be MIRASAFE as manufactured by Mirafi, Inc., or equal.

B. Physical Properties

Fence:

| | |
|---|---|
| Color: | International Orange |
| Roll Size: | 4' x 164' |
| Roll weight: | 34 lbs. |
| Mesh opening: | 1-1/2" x 3" |

Posts:

| | |
|---|---|
| ASTM Designation: | ASTM 702 |
| Length: | 5 feet long (T-Type) |
| Weight: | 1.25 #/Foot (min) |
| Area of Anchor Plate: | 14 Sq. In. |

C. Drive posts 12 to 18 inches into ground every 10' to 12'. Wrap fence material around first terminal post allowing overlap of one material opening. Use metal tie wire or plastic tie wrap to fasten material to itself at top, middle and bottom. At final post, cut with utility knife or scissors at a point halfway across an opening. Wrap around and tie at final post in the same way as the first post.

D. Use tie wire or tie wrap at intermediate posts and splices as well. Thread ties around a vertical member of the fence material and the post, and bind tightly against the post. For the most secure fastening, tie at top, middle and bottom. Overlap splices a minimum of four fence openings, tie as above, fastening both edges of the fence material splice overlap.

- END OF SECTION -

SECTION 02140

DEWATERING

PART 1 -- GENERAL

1.01 WORK INCLUDED

A. Furnish all labor, materials, and equipment, perform all work necessary to lower and control the groundwater levels and hydrostatic pressures to permit all excavations and construction to be performed in dry conditions. The work shall include the following:

1. Testing, operation, maintenance, supervision, rewatering, and final dismantling and removal from the site of the dewatering system.

2. The cost of any replacement or rehabilitation of the subgrade or structures damaged due to dewatering system failures or Contractor negligence.

3. Compliance with all regulations relating to this work.

4. The diversion, collection, and removal of all ice, snow and surface runoff from the work areas, and removal of groundwater from new excavations to permit construction in the dry.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Requirements of related work are included in Division 1 and Division 2 of these Specifications.

1.03 REFERENCE SPECIFICATIONS CODES AND STANDARDS

A. Without limiting the generality of other requirements of these Specifications, all work herein shall conform to or exceed the applicable requirements of the following documents to the extent that the provisions therein are not in conflict with the requirements of this Section.

| | | |
|---|---|---|
| 1. | ASTM D1556 | Density of soil in place by the Sand Cone Method. |
| 2. | ASTM D2167 | Density of soil in place by the Rubber Balloon Method. |
| 3. | Bureau of Reclamation | Groundwater Manual Sediment Test by Imhoff Cone |

1.04 SUBMITTALS

A. Submit the following in accordance with Section 01300, Submittals:

1. Name of dewatering subcontractor, if applicable

2. Shop Drawings indicating the following:

    a. Plans showing the methods and location of dewatering and discharge including a sufficient number of detailed sections to clearly illustrate the scope of work.

    b. Relationship of the dewatering system, observation wells, and discharge line to existing buildings, other structures, utilities, streets and new construction.

    c. Utility locations.

    d. Drawings shall bear the seal and signature of the qualified Registered Professional Engineer currently registered in the State of South Carolina in charge of preparing the drawings.

    e. List of materials and equipment to be used.

    f. A sample of all well record forms to be maintained during construction.

3. Detailed description of the sequence of dewatering operations

4. Dewatering well installation records indicating an identification number, location, dimensions, and installation procedures and materials.

5. Observation well installation records indicating an identification number, location, dimensions, and installation procedures and materials.

6. Emergency observation plan to be put into operation during failure of the dewatering system

7. Monthly Dewatering System Monitoring Reports containing the following data on approved forms:

    a. For observation wells, daily piezometric levels shall be identified by date, time, well number and system (subsystem if multiple pumps are used) pumping rate. Piezometric levels shall be noted in feet of drawdown and groundwater elevation.

    b. For dewatering wells, suspended material test results shall be identified by date, time, well number, well pumping rate (if monitored) and system (subsystem if multiple pumps are used) pumping rate.

    c. Installation records for new wells.

8. Schedule and records of all maintenance tests for primary and standby dewatering systems including the following:

    a. Maintenance tests and water quality tests for suspended matter at the discharge point including date, time of day, elapsed times of tests

procedures, components tested, suspended particles, resultant observations and well readings.

b. Daily discharge rates.

c. Installation and removal of wells.

d. General observations of the system such as equipment running times, and failures.

9. Dewatering well removal records

10. Observation well removal records

1.05 QUALITY ASSURANCE

A. The Contractor shall be solely responsible for the arrangement, location, and depths of the dewatering system necessary to accomplish the work described herein.

B. Dewatering shall prevent the loss of fines, seepage, boils, quick conditions or softening of the foundation strata while maintaining stability of the sides and bottom of the excavation, and providing dry conditions for construction operations.

PART 2 -- PRODUCTS

2.01 MATERIALS

A. Materials, especially the well screen, shall be carefully chosen to be compatible with the environment to prevent erosion, deteriorization, and clogging.

B. Surging of the natural formation to form a "gravel pack" is strictly prohibited.

PART 3 -- EXECUTION

3.01 EXAMINATION OF THE SITE

A. Become familiar with the surface and subsurface site conditions.

B. Obtain the data required to analyze the water and soil environment at the site in order to assure that the materials used for the dewatering systems will not erode, deteriorate, clog or otherwise hinder the system's performance during the period of the dewatering.

C. Prior to the execution of the work, the Contractor, Owner and Engineer shall jointly survey the condition of adjoining structures. Photographs and records shall be made of any prior settlement or cracking of structures, pavements, and the like, that may become the subject of possible damage claims.

3.02 DESIGN

A. The dewatering system shall be capable of relieving all hydrostatic pressure against the height of the excavation walls and of lowering the hydrostatic level below the bottom of the base slab a minimum of four (4) feet in the work areas both prior to excavation, and during excavation and construction.

B. The dewatering system shall be segmented so that if the operation of any one segment is disrupted, the remaining segment plus activated redundant components are capable of maintaining the groundwater at the stated levels.

C. Provide, operate and maintain all ditches, berms, site grading, sumps and pumping facilities to divert, collect and remove all surface water from work areas. All collected water shall be discharged into the outfall pipe.

D. Provide pipe and pumps of sufficient size and quantity to be able to flood the excavation within 12 hours in an emergency situation. Restoration of the working area shall be carried out by the Contractor at no additional cost to the Owner.

E. Carry the dewatering system discharge through pipes out of the area of the excavation into the outfall junction manhole shown on the Drawings. Provide meters to measure the discharge flow.

F. Place a portion of the header and discharge system underground to provide vehicle crossings or access to existing structure as required.

G. Provide a standby dewatering system that meets the following requirements:

1. Provide 100 percent standby power.

2. Provide a 15 percent minimum increase in the number of wells and related equipment required to operate the dewatering system installed and ready to operate.

3. Provide a minimum of three separate power units for the standby power system and one installed auxiliary unit for each individually powered pump.

4. Provide separate discharge lines from each well or common lines with valves such that any well or wells that malfunction or are damaged can be isolated form the others.

5. The systems shall be laid out and designed in such a way that portions of the system may be isolated for routine maintenance or repair in case of accidental damage without affecting the normal operation of the system.

H. Provide sufficient fuel to maintain a five day supply on site for fuel power systems.

I. Provide observation wells to determine compliance with dewatering requirements as indicated on the Drawings, Shop Drawings, and the Engineer.

J. Designate certain observation wells as emergency observation wells.

3.03 INSPECTION

A. All tests and inspections require the witnessing and written approval of the Owner and Engineer.

B. Provide safe access for the owner and Engineer to perform testing and inspection.

C. The Owner and Engineer will provide oral and written notice to the Contractor for all tests and inspections that do not meet approval.

3.04 INSTALLATION AND TESTING

A. Install the dewatering system from the existing ground surface or from the bottom of an excavation which is located above the natural groundwater level.

B. Pump each well individually at its maximum or design flow and take a water sample using the following procedures:

1. Obtain samples from stopcocks located along the discharge lines at points of high turbulence or between 4 and 8 o'clock on the perimeter of straight sections of pipe.

2. Flush the stopcock for a few seconds before taking a sample.

3. Take a 1 liter sample with the stopcock fully open.

C. Test the sample following the Sediment Test by Imhoff Cone for two to three minutes and measure the volume of settled materials to the nearest 0.01 milliliters (0.01 milliliters = 10 ppm).

D. All wells shall be evaluated as follows:

1. Wells producing 10 ppm or less shall be accepted.

2. Wells producing between 10 and 20 ppm may be accepted by the Engineer based on the evaluation of average ppm for all wells, ppm of adjacent wells, and total quantity of water which is actually pumped to dewater the excavation.

3. Well producing more than 20 ppm shall be abandoned and backfilled.

E. Observation wells shall consist of a standpipe or riser of minimum 1.0-inch inside diameter and a minimum three (3) foot long well-point screen or slotted PVC section at the bottom. Observation wells shall be installed as follows:

1. Employ the jetting method for all observation wells except those within ten feet of existing structures, piping or utilities.

2. Employ Case Boring Techniques for all observation wells within ten feet of existing structures, piping, or utilities and backfill the annulus between the well point or riser and the natural soil with a free flowing granular material similar to Ottawa Sand.

F. Test observation wells by adding or removing water from the riser to demonstrate their proper functioning.

3.05 DEWATERING PROCEDURE

A. Following excavation support system installation and dewatering system installation and testing and prior to excavation, place the dewatering system into operation and lower the water level.

B. Schedule the dewatering work to coordinate with all the other related work such as excavation, excavation support installation, placement of concrete walls and slabs, and any other operations by other Contractors that might be affected by this work.

C. Test the standby dewatering system with the following procedures:

1. Shut off the primary power source and demonstrate that the standby power can be activated prior to the groundwater level rising to within one (1) foot of the bottom of base slab elevation and that the standby power source is adequate to draw the groundwater level back down to the Contractor's design depth or to the minimum required depths.

2. Shut off one segment of the system and show that redundant components can be activated prior to the groundwater level rising to within one (1) foot of the bottom of base slab elevation and that the system is adequate to draw the groundwater level back down to the Contractor's design depth or to the minimum required depths.

3. If the dewatering system fails to meet either performance requirement, the Contractor shall draw the groundwater level to a greater depth, add wells, or modify the system such that it will be in conformance with these requirements when retested.

D. Operate the dewatering system continuously twenty-four (24) hours per day, seven (7) days per week until all structures have been satisfactorily constructed, including placement of fill materials, and no longer require dewatering.

3.06 MONITORING

A. Measure the piezometric water levels to the nearest one-tenth foot in all observation wells and submit the readings daily.

B. Measure the concentration of suspended material in the discharge water of each well once every two days. Wells which exceed the acceptable level of solids concentration shall be replaced.

C. Test the performance of the standby system and all components by demonstrating that the system is operational at least every two weeks.

D. Test the observation wells every two weeks by adding and removing water from the risers to demonstrate their proper functioning.

E. Observation wells that become inoperable shall be immediately replaced while construction is halted if the Engineer determines that the observation well is critical.

F. Remove and add riser pipe of each observation well located within the excavation as construction progresses until the well conflicts with the structure. When the conflict occurs, abandon the observation well, fill it with grout, and cut the riser off at grade.

G. In the event of a dewatering system failure, take the following steps:

1. Conduct in situ density tests conforming to ASTM D1556 or ASTM D2167 immediately above and at the structure founding grades.

2. Remove all soils that show unacceptable density and replace them with compacted fill as indicated in Section 02200, Earthwork.

3. Test the repaired soils as required by the Owner and Engineer to verify that they have been returned to their original in situ state or better.

4. Repair or replace damaged structures.

3.07 REWATERING AND REMOVAL OF DEWATERING SYSTEM

A. Obtain written approval from the Owner and Engineer to being rewatering operations.

B. Provide an adequate weight of fill to prevent buoyancy.

C. Pump water into the excavation such that the water level inside the excavation is always at a higher level than the rising groundwater on the outside until the groundwater level has reached its static level.

D. Remove all dewatering wells, buried and surface piping, cables, pump foundations, structural supports and all other support facilities.

E. Backfill as specified in Section 02200, Earthwork, all trenches and excavations below final grades or in fill areas.

F. Provide documentation of dewatering and observation well removal including the date of removal, well number, location, procedures, and materials used.

- END OF SECTION -

SECTION 02200

EARTHWORK

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Furnish all labor, equipment and materials required to complete all work associated with excavation, including off-site borrow excavation, dewatering, backfill, drainage layers beneath and around structures, foundation and backfill stone, filter fabric, embankments, stockpiling topsoil and any excess suitable material in designated areas, in place compaction of embankments, backfill and subgrades beneath foundations and roadways, excavation support, disposing from the site all unsuitable materials, providing erosion and sedimentation control grading, site grading and preparation of pavement and structure subgrade, and other related and incidental work as required to complete the work shown on the Drawings and specified herein.

B. All excavations shall be in conformity with the lines, grades, and cross sections shown on the Drawings or established by the Engineer.

C. It is the intent of this Specification that the Contractor conduct the construction activities in such a manner that erosion of disturbed areas and off-site sedimentation be absolutely minimized.

D. All work under this Contract shall be done in conformance with and subject to the limitations of the latest editions of the South Carolina State Highway Department Standard Specifications for Highway Construction.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Requirements of related work are included in Division 1 and Division 2 of these Specifications.

1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Without limiting the generality of the other requirements of the Specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced Specifications, codes, and standards refer to the most current issue available at the time of Bid.

1. South Carolina State Highway Department Standard Specifications for Highway Construction.

2. American Society for Testing and Materials (ASTM):

ASTM C 127 Test for Specific Gravity and Absorption of Coarse Aggregate.

| | |
|---|---|
| ASTM C 136 | Test for Sieve Analysis of Fine and Coarse Aggre |
| ASTM D 422 | Particle Size Analysis of Soils. |
| ASTM D 423 | Test for Liquid Limit of Soils. |
| ASTM D 424 | Test for Plastic Limit and Plasticity Index of Soils. |
| ASTM C 535 | Test for Resistance to Degradation of Large Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine. |
| ASTM D 698 | Standard Method of Test for the Moisture - Density Relations of Soils Using a 5.5 lb. (2.5 kg) Rammer and a 12-inch (305 mm) Drop. |
| ASTM D1556 | Test for Density of Soil in Place by the Sand-Cone Method. |
| ASTM D1557 | Test for Moisture-Density Relations of Soils and Soil Aggregate Mixtures Using 10-lbs. (4.5 kg) Rammer and 18-inch (457 mm) Drop. |
| ASTM D2049 | Test Method for Relative Density of Cohesionless Soils. |
| ASTM D2167 | Test for Density of Soil in Place by the Rubber-Balloon Method. |
| ASTM D2216 | Test for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil Aggregate Mixtures. |
| ASTM D2487 | Test for Classification of Soils for Engineering Purposes. |
| ASTM D2922 | Test for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth). |

1.04 SUBSURFACE CONDITIONS

A. Information on subsurface conditions is referenced under Division 1, General Requirements.

B. Attention is directed to the fact that there may be water pipes, storm drains and other utilities located in the area of proposed excavation. Perform all repairs to same in the event that excavation activities disrupt service.

1.05 SUBMITTALS

A. In accordance with the procedures and requirements set forth in Section 01300 - Submittals, the Contractor shall submit the following:

1. Name and location of all material suppliers.

2. Certificate of compliance with the standards specified above for each source of each material.

3. List of disposal sites for waste and unsuitable materials and all required permits for use of those sites.

4. Samples of synthetic filter fabric with manufacturer's certificates or catalog cuts stating the mechanical and physical properties. Samples shall be at least one (1) foot wide and four (4) feet long taken across the roll with the warp direction appropriately marked.

5. Monitoring plan and pre-construction condition inspection and documentation of all adjacent structures, utilities, and roadways near proposed installation of excavation support systems and near areas where dewatering is required to facilitate construction.

1.06 PRODUCT HANDLING

A. Soil and rock material shall be excavated, transported, placed, and stored in a manner so as to prevent contamination, segregation and excessive wetting. Materials which have become contaminated or segregated will not be permitted in the performance of the work and shall be removed from the site.

1.07 USE OF EXPLOSIVES

A. Use of explosive for excavation purposes will not be permitted on site.

PART 2 -- PRODUCTS

2.01 MATERIALS AND CONSTRUCTION

A. Earthwork Materials
   1. Fill Material, General
      a. Approval Required: All fill material shall be subject to the approval of the OWNER.
      b. Notification: For approval of imported fill material, notify the OWNER at least one week in advance of intention to import material, designate the proposed borrow area and permit the OWNER to sample as necessary from the borrow area for the purpose of making acceptance tests to prove the quality of the material.

   2. On-Site Fill Material: Soil exclusive of organic matter, frozen lumps or other deleterious substances, and containing no rocks larger than 2 inches or lumps larger than 3 inches.

   3. Imported Fill Materials: Meet the requirements of on-site fill material.

   4. Sand Cushions and Sand Fill: Consists of a sand-gravel fill of such gradation that 100 percent will pass a 3/8-inch sieve and not more than 10 percent by weight is lost by washing.

5. Coarse Aggregate: Conform to the SCDOT SSHC 306.03 (SCDOT Aggregate No. 57) and having the following gradation:

| SIEVE DESIGNATION | PERCENT BY WEIGHT PASSING |
|---|---|
| 2-inch | - |
| 1-1/2-inch | 100 |
| 1-inch | 95-100 |
| 1/2-inch | 25-60 |
| No. 4 | 0-10 |
| No. 8 | 0-5 |

6. Drainage Aggregate: Conform to the SCDOT SSHC Section 801.02 (SCDOT Aggregate No. 789) and having the following gradation:

| SIEVE DESIGNATION | PERCENT BY WEIGHT PASSING |
|---|---|
| 3/4-inch | 100 |
| 1/2-inch | 95-100 |
| 3/8-inch | 80-100 |
| No. 4 | 20-50 |
| No. 16 | 0-6 |
| No. 100 | 0-2 |

7. Fine Aggregate: Conform to the SCDOT SSHC 306.04 and having the following gradation:

| SIEVE DESIGNATION | PERCENT BY WEIGHT PASSING |
|---|---|
| No. 4 | 100 |
| No. 16 | 25-75 |
| No. 100 | 0-25 |

8. Pea Gravel: Clean, naturally rounded aggregate, 1/8 to 3/4-inch in diameter per ASTM C 33.
9. Topsoil: Dark organic weed free loam; free of muck, roots, rocks larger than 1/2 inch, subsoil, and foreign matter.

2.02 SELECT FILL

A. Soils from the excavations meeting requirements stipulated herein with the exceptions of topsoil and organic material may be used as select fill for backfilling, constructing embankments, reconstructing existing embankments, and as structural subgrade support. Sample existing soil conditions before bidding to confirm if excavations will require select fill.

B. Select fill used for embankment construction shall be a silty or clayey soil material with a Maximum Liquid Limit (LL) of 50 and a Plasticity Index (PI) between 7 and 20.

C. Select fill used for backfilling shall either be material as described in Paragraph B above or a granular soil material with a Maximum Plasticity Index (PI) of 6.

D. Regardless of material used as select fill, materials shall be compacted at a moisture content satisfactory to the Engineer, which shall be approximately that required to produce the maximum density except that the moisture content shall not be more than 2% below nor more than 2% above the optimum moisture content for the particular material tested in accordance with the ASTM D698.

E. Select fill used as subgrade support shall be a coarse aggregate material meeting the gradation requirements of #57 or #78 aggregates in accordance with ASTM C-33, or Aggregate Base Course (ABC) as defined in Section 02207 – Aggregate Materials.

F. Where excavated material does not meet requirements for select fill, Contractor shall furnish off-site borrow material meeting the specified requirements herein. Determination of whether the borrow material will be paid for as an extra cost will be made based on Article 4 of the General Conditions, as amended by the Supplementary Conditions. When the excavated material from required excavations is suitable for use as backfill, bedding, or embankments, but is replaced with off-site borrow material for the Contractor's convenience, the costs associated with such work and material shall be borne by the Contractor.

2.03 TOPSOIL

A. Topsoil shall be considered the surface layer of soil and sod, suitable for use in seeding and planting. It shall contain no mixture of refuse or any material toxic to plant growth.

2.04 GEOTEXTILES

A. The Contractor shall provide geotextiles as indicated on the Drawings and specified herein. The materials and placement shall be as indicated under Section 02274 - Geotextiles.

## PART 3 -- EXECUTION

3.01 SAFETY

A. Comply with local regulations and with the provisions of the "Manual of Accident Prevention in Construction" of the Associated General Contractors of America, Inc., Occupational Safety and Health Act and all other applicable safety regulations.

3.02 STRIPPING OF TOPSOIL

A. In all areas to be excavated, filled, paved, or graveled the topsoil shall be stripped to its full depth and shall be deposited in storage piles on the site, at locations designated by the Engineer, for subsequent reuse. Topsoil shall be kept separated from other excavated materials and shall be piled free of roots and other undesirable materials.

3.03 EXCAVATION

A. All material excavated, regardless of its nature or composition, shall be classified as UNCLASSIFIED EXCAVATION. Excavation shall include the removal of all soil, rock, weathered rock, rocks of all types, boulders, conduits, pipe, and all other obstacles encountered and shown to be removed within the limits of excavation shown on the Drawings or specified herein. The cost of excavation shall be included in the Lump Sum Bid Price and no additional payment will be made for the removal of obstacles encountered within the excavation limits shown on the Drawings and specified herein.

B. Blasting or other use of explosives shall not be used for excavation purposes.

C. All suitable material removed in the excavation shall be used as far as practicable in the formation of embankments, subgrades, and shoulders, and at such other places as may be indicated on the Drawings or indicated by the Engineer. No excavation shall be wasted except as may be permitted by the Engineer. Refer to the drawings for specific location and placement of suitable excavated materials in the formation of embankments, backfill, and structural and roadway foundations. THE ENGINEER AND/OR MATERIALS TESTING CONSULTANT WILL DESIGNATE MATERIALS THAT ARE UNSUITABLE. The Contractor shall furnish off site disposal areas for the unsuitable material. Where suitable materials containing excessive moisture are encountered above grade in cuts, the Contractor shall construct above grade ditch drains prior to the excavation of the cut material when in the opinion of the Engineer and/or materials testing consultant such measures are necessary to provide proper construction.

D. All excavations shall be made in the dry and in such a manner and to such widths as will give ample room for properly constructing and inspecting the structures and/or piping they are to contain and for such excavation support, pumping and drainage as may be required. Excavation shall be made in accordance with the grades and details shown on the Drawings and as specified herein.

E. Excavation slopes shall be flat enough to avoid slides that will cause disturbance of the subgrade or damage of adjacent areas. Excavation requirements and slopes shall be as indicated in the Drawings. The Contractor shall intercept and collect surface runoff both at the top and bottom of cut slopes. The intersection of slopes with natural ground surfaces, including the beginning and ending of cut slopes, shall be uniformly rounded as shown on the Drawings or as may be indicated by the Engineer. Concurrent with the excavation of cuts the Contractor shall construct intercepting berm ditches or earth berms along and on top of the cut slopes at locations shown on the Drawings or designated by the Engineer. All slopes shall be finished to reasonably uniform surfaces acceptable for seeding and mulching operations. No rock or boulders shall be left in place which protrude more than 1 foot within the typical section cut slope lines, and all rock cuts shall be cleaned of loose and overhanging material. All protruding roots and other objectionable vegetation shall be removed from slopes. The Contractor shall be required to submit plans of open-cut excavation for review by the Engineer before approval is given to proceed.

F. It is the intent of these Specifications that all structures shall bear on an aggregate base, crushed stone or screened gravel bedding placed to the thickness shown on the Drawings, specified in these Specifications, or not less than 6-inches. Bedding for process piping shall be as specified in Section 15000 - Basic Mechanical Requirements, or as shown on the Drawings.

G. The bottom of all excavations for structures and pipes shall be examined by the Engineer and/or materials testing consultant for bearing value and the presence of unsuitable material. If, in the opinion of the Engineer and/or materials testing consultant, additional excavation is required due to the low bearing value of the subgrade material, or if the in-place soils are soft, yielding, pumping and wet, the Contractor shall remove such material to the required width and depth and replace it with thoroughly compacted select fill, and/or crushed stone or screened gravel as indicated by the Engineer. Payment for such additional work ordered by the Engineer shall be made as an extra by a Change Order in accordance with the General Conditions and Division 1. No payment will be made for subgrade disturbance caused by inadequate dewatering or improper construction methods.

H. All cuts shall be brought to the grade and cross section shown on the Drawings, or established by the Engineer, prior to final inspection and acceptance by the Engineer.

I. Slides and overbreaks which occur due to negligence, carelessness or improper construction techniques on the part of the Contractor shall be removed and disposed of by the Contractor as indicated by the Engineer at no additional cost to the Owner. If grading operations are suspended for any reason whatsoever, partially completed cut and fill slopes shall be brought to the required slope and the work of seeding and mulching or other required erosion and sedimentation control operations shall be performed.

3.04 EXCAVATION SUPPORT

A. The Contractor shall furnish, place, and maintain such excavation support which may be required to support sides of excavation or to protect pipes and structures from possible damage and to provide safe working conditions. If the Engineer is of the opinion that at any point sufficient or proper supports have not been provided, he may order additional supports put in at the expense of the Contractor. The Contractor shall be responsible for the adequacy of all supports used and for all damage resulting from failure of support system or from placing, maintaining and removing it.

B. Selection of and design of any proposed excavation support systems is exclusively the responsibility of the Contractor. Contractor shall submit drawings and calculations on proposed systems sealed by a Professional Engineer currently registered in the State of South Carolina.

C. The Contractor shall exercise caution in the installation and removal of supports to insure that excessive or unusual loadings are not transmitted to any new or existing structure. The Contractor shall promptly repair at his expense any and all damage that can be reasonably attributed to installation or removal of excavation support system.

D. Contractor shall monitor movement in the excavation support systems as well as movement at adjacent structures, utilities and roadways near excavation supports. Contractor shall submit a monitoring plan developed by the excavation support design engineer. All pre-

construction condition assessment and documentation of adjacent structures on-site and off-site shall be performed by the Contractor. If any sign of distress such as cracking or movement occurs in any adjacent structure, utility or roadway during installation of supports, subsequent excavation, service period of supports, subsequent backfill and construction, or removal of supports, Engineer shall be notified immediately. Contractor shall be exclusively responsible for repair of any damage to any roadway, structure, utility, pipes, etc. both on-site and off-site, as a result of his operations.

E. All excavation supports shall be removed upon completion of the work except as indicated herein. The Engineer may permit supports to be left in place at the request and expense of the Contractor. The Engineer may order certain supports left permanently in place in addition to that required by the Contract. The cost of the materials so ordered left in place, less a reasonable amount for the eliminated expense of the removal work omitted, will be paid as an extra by a Change Order in accordance with the General Conditions and Division 1. Any excavation supports left in place shall be cut off at least two (2) feet below the finished ground surface or as directed by the Engineer.

3.05 PROTECTION OF SUBGRADE

A. To minimize the disturbance of bearing materials and provide a firm foundation, the Contractor shall comply with the following requirements:

1. Use of heavy rubber-tired construction equipment shall not be permitted on the final subgrade unless it can be demonstrated that drawdown of groundwater throughout the entire area of the structure is at least 3 feet below the bottom of the excavation (subgrade). Even then, the use of such equipment shall be prohibited should subgrade disturbance result from concentrated wheel loads.

2. Subgrade soils disturbed through the operations of the Contractor shall be excavated and replaced with compacted select fill or crushed stone at the Contractor's expense as indicated by the Engineer.

3. The Contractor shall provide positive protection against penetration of frost into materials below the bearing level during work in winter months. This protection can consist of a temporary blanket of straw or salt hay covered with a plastic membrane or other acceptable means.

3.06 PROOFROLLING

A. The subgrade of all structures and all areas that will support pavements or select fill shall be proofrolled. After stripping of topsoil, excavation to subgrade and prior to placement of fills, the exposed subgrade shall be carefully inspected by probing and testing as needed. Any topsoil or other organic material still in place, frozen, wet, soft, or loose soil, and other undesirable materials shall be removed. The exposed subgrade shall be proofrolled with a heavily loaded tandem-wheeled dump truck to check for pockets of soft material hidden beneath a thin crust of better soil. Any unsuitable materials thus exposed shall be removed and replaced with an approved compacted material.

3.07 DEWATERING

A. Dewatering operations shall be conducted as specified in Section 02140 Dewatering.

3.08 EMBANKMENTS

A. The Contractor shall perform the construction of embankments in such a manner that cut and fill slopes will be completed to final slopes and grade in a continuous operation. The operation of removing excavation material from any cut and the placement of embankment in any fill shall be a continuous operation to completion unless otherwise permitted by the Engineer.

B. Surfaces upon which embankments are to be constructed shall be stripped of topsoil, organic material, rubbish and other extraneous materials. After stripping and prior to placing embankment material, the Contractor shall compact the top 12-inches of in place soil as specified under Paragraph 3.09, COMPACTION.

C. Any soft or unsuitable materials revealed before or during the in place compaction shall be removed as indicated by the Engineer and/or materials testing consultant and replaced with select fill.

D. Ground surfaces on which embankment is to be placed, shall be scarified or stepped in a manner which will permit bonding of the embankment with the existing surface. The embankment soils shall be as specified under Part 2 - Products, and shall be deposited and spread in successive, uniform, approximately horizontal layers not exceeding 8-inches in compacted depth for the full width of the cross section, and shall be kept approximately level by the use of effective spreading equipment. Hauling shall be distributed over the full width of the embankment, and in no case will deep ruts be allowed to form during the construction of the embankment. The embankment shall be properly drained at all times. Each layer of the embankment shall be thoroughly compacted to the density specified under Paragraph 3.09, COMPACTION.

E. The embankment or fill material in the layers shall be of the proper moisture content before rolling to obtain the prescribed compaction. Wetting or drying of the material and manipulation when necessary to secure a uniform moisture content throughout the layer shall be required. Should the material be too wet to permit proper compaction or rolling, all work on all portions of the embankment thus affected shall be delayed until the material has dried to the required moisture content. Samples of all embankment materials for testing, both before and after placement and compaction, will be taken at frequent intervals. From these tests, corrections, adjustments, and modifications of methods, materials, and moisture content will be made to construct the embankment.

F. Where embankments are to be placed and compacted on hillsides, or when new embankment is to be compacted against embankments, or when embankment is built in part widths, the slopes that are steeper than 4:1 shall be loosened or plowed to a minimum depth of 6 inches or, if in the opinion of the Engineer, the nature of the ground is such that greater precautions should be taken to bind the fill to the original ground then benches shall be cut in the existing ground as indicated by Engineer.

G. When rock and other embankment material are excavated at approximately the same time, the rock shall be incorporated into the outer portions of the embankments and the other material which meets the requirements for select fill shall be incorporated into the formation

of the embankments. Stones or fragmentary rock larger than 4-inches in their greatest dimension will not be allowed within the top 6-inches of the final grade. Stones, fragmentary rock, or boulders larger than 12-inches in their greatest dimension will not be allowed in any portions of embankments and shall be disposed of by the Contractor as indicated by the Engineer. When rock fragments or stone are used in embankments, the material shall be brought up in layers as specified or directed and every effort shall be exerted to fill the voids with finer material to form a dense, compact mass which meets the densities specified for embankment compaction.

3.09 BACKFILLING

A. All structures and pipes shall be backfilled with the type of materials shown on the Drawings and specified herein. Select fill shall be deposited in successive, uniform, approximately horizontal layers not exceeding 8-inches in compacted depth for the full width. Stones or fragmentary rock larger than 4-inches in their greatest dimension will not be allowed within the top 6-inches of the ground nor within 6 inches of pipes. No stone or fragmentary rock larger than 12-inches in their greatest dimension will be allowed for any portion of backfill. Compaction shall be in accordance with the requirements of Paragraph 3.09, COMPACTION.

B. Where excavation support is used, the Contractor shall take all reasonable measures to prevent loss of support beneath and adjacent to pipes and existing structures when supports are removed. If significant volumes of soil cannot be prevented from clinging to the extracted supports, the voids shall be continuously backfilled as rapidly as possible. The Contractor shall thereafter limit the depth below subgrade that supports will be installed in similar soil conditions or employ other appropriate means to prevent loss of support.

3.10 COMPACTION

A. The Contractor shall compact embankments, backfill, crushed stone, aggregate base, and in place subgrade in accordance with the requirements of this Section. The densities specified herein refer to percentages of maximum density as determined by the noted test methods. Compaction of materials on the project shall be in accordance with the following schedule:

| | Density % Std. Proctor (D698) | Density % Mod. Proctor (D1557) | Max. Lift Thickness as Compacted Inches |
|---|---|---|---|
| Embankments Beneath Structures* | 98 | 95 | 8 |
| Other Embankments | 95 | 92 | 8 |
| Backfill Around Structures | 95 | 92 | 8 |
| Backfill in Pipe Trenches | 95 | 92 | 8 |
| Crushed Stone Beneath Structures | ** | ** | 12 |
| Select Sand | -- | 98 | 8 |
| Aggregate Base Course (ABC) Beneath Pavements and Structures | -- | 98 | 8 |

| | Density % Std. Proctor (D698) | Density % Mod. Proctor (D1557) | Max. Lift Thickness as Compacted Inches |
|---|---|---|---|
| Crushed Stone Backfill | ** | ** | 12 |
| Crushed Stone Pipe Bedding | ** | ** | 12 |
| In place Subgrade Beneath Structures | 98 | 95 | Top 12-inches |

* Embankments beneath structures shall be considered to include a zone 10 feet out from the foundation of the structure extending down to the natural ground on a 45° slope.

** The aggregate shall be compacted to a degree acceptable to the Engineer by use of a vibratory compactor and/or crawler tractor.

B. Field density tests will be made by the materials testing consultant to determine if the specified densities have been achieved, and these tests shall be the basis for accepting or rejecting the compaction. In-place density tests will be performed in accordance with ASTM D 1556, ASTM D 2167, or ASTM D 2922. The Engineer in conjunction with the materials testing consultant will be the judge as to which test method will be the most appropriate. Failure to achieve the specified densities shall require the Contractor to re-compact the material or remove it as required. The Contractor shall, if necessary, increase his compactive effort by increasing the number of passes, using heavier or more suitable compaction equipment, or by reducing the thickness of the layers. The Contractor shall adjust the moisture contents of the soils to bring them within the optimum range by drying them or adding water as required.

C. Testing will be performed as frequently as deemed necessary by the Engineer and/or materials testing consultant. As a minimum, one in-place density test shall be performed for each 1000 cubic yards of embankment placed and 500 cubic yards of backfill placed or one test performed each day for either.

3.11 REMOVAL OF EXCESS AND UNSUITABLE MATERIALS

A. The Contractor shall remove and dispose of off-site all unsuitable materials. Within thirty (30) consecutive days after Notice to Proceed, the Contractor shall submit to the Engineer for review all required permits and a list of disposal sites for the unsuitable materials. If the disposal site is located on private property, the submittal shall also include written permission from the owner of record.

B. All unsuitable materials shall be disposed of in locations and under conditions that comply with federal, state and local laws and regulations.

C. The Contractor shall obtain an off-site disposal area prior to beginning demolition or excavation operations.

D. All excess and unsuitable materials shall be hauled in trucks of sufficient capacity and tight construction to prevent spillage. Trucks shall be covered to prevent the propagation of dust.

E. When all excess and unsuitable material disposal operations are completed, the Contractor shall leave the disposal sites in a condition acceptable to the Owner and Owner(s) of the disposal site(s).

## 3.12 BORROW EXCAVATION

A. Description

The work covered by this section consists of the excavation of approved material from borrow sources and the hauling and utilization of such material as required on the Drawings or directed by the Engineer. It shall also include the removing, stockpiling, and replacement of topsoil on the borrow source; the satisfactory disposition of material from the borrow source which is not suitable for use; and the satisfactory restoration of the borrow source and haul roads to an acceptable condition upon completion of the work.

Borrow excavation shall not be used before all available suitable unclassified excavation has been used for backfill and incorporated into the embankments.

B. Coordination with Seeding Operations

The Contractor shall coordinate the work covered by this section with the construction of embankments so that the requirements of Section 02200 are met.

C. Materials

All material shall meet the requirements of Division 2 shown below:

Borrow Material.....Section 02200, Subsection 2.01 - Select Fill

D. Construction Methods

1. General

The surface of the borrow area shall be thoroughly cleared and grubbed and cleaned of all unsuitable material including all organics, topsoil, etc., before beginning the excavation. Disposal of material resulting from clearing and grubbing shall be in accordance with Section 02100.

Each borrow operation shall not be allowed to accumulate exposed, erodible slope area in excess of 1 acre at any one given time without the Contractor's beginning permanent seeding and mulching of the borrow source or other erosion control measures as may be approved by the Engineer.

The topsoil shall be removed and stockpiled at locations that will not interfere with the borrow operations and that meet the approval of the Engineer. Temporary erosion control measures shall be installed as may be necessary to prevent the erosion of the stockpile material. Once all borrow has been removed from the source or portion thereof, the stockpiled topsoil shall be spread uniformly over the source.

Where it is necessary to haul borrow material over existing roads, the Contractor shall use all necessary precautions to prevent damage to the existing roads. The Contractor shall also conduct his hauling operations in such a manner as to not interfere with the normal flow of traffic and shall keep the traffic lanes free from spillage at all times.

2. Owner Furnished Sources

Where borrow sources are furnished by the Owner the location of such sources will be as designated on the Drawings or as directed by the Engineer.

The Owner will furnish the necessary haul road right-of-way at locations designated by the Engineer. All haul roads required shall be built, maintained, and when directed by the Engineer, obliterated, at no cost to the Owner. Where the haul road is to be reclaimed for cultivation the Contractor shall plow or scarify the area to a minimum depth of 8 inches.

The borrow sources shall be left in a neat and presentable condition after use. All slopes shall be smoothed, rounded, and constructed not steeper than 3:1. Where the source is to be reclaimed for cultivation the source shall be plowed or scarified to a minimum depth of 8 inches, disc harrowed, and terraces constructed. The source shall be graded to drain such that no water will collect or stand and a functioning drainage system shall be provided.

All sources shall be seeded and mulched in accordance with Section 02910.

3. Contractor Furnished Sources

Prior to the approval of any off-site borrow source(s) developed for use on this project, the Contractor shall obtain certification from the State Historic Preservation Officer of the State Department of Cultural Resources certifying that the removal of the borrow material from the borrow source(s) will have no effect on any known district, site building, structure, or object that is included or eligible for inclusion in the National Register of Historic Places. A copy of this certification shall be furnished to the Engineer prior to performing any work on the proposed borrow source.

The approval of borrow sources furnished by the Contractor shall be subject to the following conditions:

a. The Contractor shall be responsible for acquiring the right to take the material and any rights of access that may be necessary; for locating and developing the source; and any clearing and grubbing and drainage ditches necessary.

Such right shall be in writing and shall include an agreement with the Owner that the borrow source may be dressed, shaped, seeded, mulched, and drained as required by these Specifications after all borrow has been removed.

b. Except where borrow is to be obtained from a commercial source, the Contractor and the property owner shall jointly submit a borrow source development, use, and reclamation plan to the Engineer for his approval prior to engaging in any land disturbing activity on the proposed source other than material sampling that may be necessary. The Contractor's plan shall address the following:

(1) Drainage

The source shall be graded to drain such that no water will collect or stand and a functioning drainage system shall be provided. If drainage is not practical, and the source is to serve as a pond, the minimum average depth below the water table shall be 4 feet or the source graded so as to create wetlands as appropriate.

(2) Slopes

The source shall be dressed and shaped in a continuous manner to contours which are comparable to and blend in with the adjacent topography, but in no case will slopes steeper than 3:1 be permitted.

(3) Erosion Control

The plan shall address the temporary and permanent measures that the Contractor intends to employ during use of the source and as a part of the reclamation. The Contractor's plan shall provide for the use of staged permanent seeding and mulching on a continual basis while the source is in use and the immediate total reclamation of the source when no longer needed.

4. Maintenance

During construction and until final acceptance the Contractor shall use any methods approved by the Engineer which are necessary to maintain the work covered by this section so that the work will not contribute to excessive soil erosion.

- END OF SECTION -

SECTION 02276

EROSION AND SEDIMENTATION CONTROL

PART 1 -- GENERAL

1.01 THE REQUIREMENTS

A. The Contractor is responsible for implementing Best Management Practices (BMP's) to prevent and minimize erosion and resultant sedimentation in all cleared and grubbed areas during and after construction in accordance with South Carolina Department of Health and Environmental Control (SCDHEC) Stormwater Management requirements. This item covers the work necessary for the installation of structure and measures for the prevention and control of soil erosion. The Contractor shall furnish all material, labor and equipment necessary for the proper installation, maintenance, inspection, monitoring, reporting, and removal (where applicable) of erosion prevention and control measures as required to complete the work on the Drawings and specified herein.

B. All excavations shall be in conformity with the lines, grades, and cross sections shown on the Drawings or established by the Engineer.

C. It is the intent of this Specification that the Contractor conducts the construction activities in such a manner that erosion of disturbed areas and off site sedimentation be absolutely minimized.

D. All work under this Contract shall be done in conformance with and subject to the limitations of the South Carolina Stormwater Management and Sediment Reduction Act (Section R.72-307) and local erosion control and stormwater management ordinances.

E. The following excerpts from the regulations are particularly important:

1. All sediment control measures shall be inspected at least once seven calendar days and after any storm event of greater than 0.5 inches of precipitation during any 24-hour period. All sediment control features shall be maintained until final stabilization has been obtained.

2. Stabilization measures shall be initiated as soon as practicable in portions of the site where construction activities have temporarily or permanently ceased, but in no case more than 14 days after the construction activity in that portion of the site has temporarily or permanently ceased, unless activity in that portion of the site will resume within 21 days.

F. Due to the nature of the work required by this Contract, it is anticipated that the location and nature of the erosion and sedimentation control devices will be adjusted on several occasions to reflect the current phase of construction. The construction schedule adopted by the Contractor will impact the placement and need for specific devices required for the control of erosion. The Contractor shall develop and implement such additional techniques

as may be required to minimize erosion and off-site sedimentation. The location and extent of erosion and sedimentation control devices shall be revised at each phase of construction that results in a change in either the quantity or direction of surface runoff from constructed areas. All deviations from the erosion and sedimentation control provisions shown on the Drawings shall have the prior acceptance of the Engineer.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 02100 - Clearing, Grubbing, and Site Preparation

B. Section 02200 – Earthwork

C. Section 02910 - Final Grading and Landscaping

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Without limiting the generality of other requirements of these specifications, all work hereunder shall conform to the applicable requirements of the referenced portions of the following documents, to the extent that the requirements therein are not in conflict with the provisions of this Section.

1. Section R.72-307, South Carolina Stormwater Management and Sediment Reduction Act.

2. SCDHEC Stormwater Management BMP Handbook, latest edition.

B. See Specification Section 01090 - Reference Standards.

1.04 REGULATORY COMPLIANCE

A. Contractor shall comply with requirements specified in the Contract Documents or by the Engineer. Contractor shall also comply with all other laws, rules, regulations, ordinances and requirements concerning soil erosion and sediment control established in the United States and the State of South Carolina.

1.05 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions Division 1 and Section 01300 - Submittals, the Contractor shall submit the following:

1. Name and location of all material suppliers.

2. Certificate of compliance with the standards specified above for each source of each material.

3. List of disposal sites for waste and unsuitable materials and all required permits for use of those sites.

1.06 GUARANTEE

A. All restoration and revegetation work shall be subject to the one-year guarantee period of the Contract as specified in the General Conditions.

## PART 2 -- MATERIALS

### 2.01 MATERIALS

A. Materials for use in erosion and sedimentation control devices shall be in accordance with these specifications and the South Carolina Stormwater Management and Sediment Control Handbook.

### 2.02 SEDIMENT TRAPS

A. Temporary sediment traps shall be constructed as shown on the Contract Drawings and as specified herein. The temporary sediment traps shall be constructed and maintained in accordance with Part 3 of this Section and in accordance with the notes on the Drawings to the satisfaction of the Engineer until a vegetative ground cover has been established. The cost of the temporary sediment basins shall be included in the erosion control measures line item in the contract and shall include the excavation, grading, stone for erosion control, washed stone, geotextile, etc. and all maintenance activities required.

### 2.03 PIPE SLOPE DRAINS

A. Pipe Slope Drains shall be constructed as shown on the Contract Drawings and as specified herein. Pipe Slope Drains shall be constructed and maintained in accordance with Part 3 of this Section and in accordance with the notes on the Drawings to the satisfaction of the Engineer until a vegetative ground cover has been established. The cost of Pipe Slope Drains shall include the excavation and all maintenance and restoration activities required.

### 2.04 REINFORCED SILT FENCE

A. Reinforced Silt Fence shall be a woven geotextile filter fabric made specifically for sediment control. Filter fabric shall not rot when buried and shall resist attack from soil chemicals, alkalies and acids in the pH range from 2 to 13, and shall resist damage due to prolonged ultraviolet exposure. Filter fabric shall be of manufacturer acceptable to Anderson County Stormwater or equal. Reinforced Silt Fence shall be constructed and maintained in accordance with Part 3 of this Section and in accordance with the notes on the Drawings to the satisfaction of the Engineer until a vegetative ground cover has been established.

B. Filter fabric for the silt fence shall have the following minimum properties:

| | Value | Test Method |
|---|---|---|
| Grab Tensile Strength | 50 lbs | ASTM D 4632 |
| Grab Elongation | 15% | ASTM D 4632 |

| | | |
|---|---|---|
| Trapezoid Tear Strength | 50 lbs | ASTM D 4533 |
| Mullen Burst Strength | 265 lbs | ASTM D 3786 |
| Puncture Strength | 58 lbs | ASTM D 4833 |
| Retained Strength (500 hrs. accelerated UV exposure) | 80% | ASTM D 4355 |
| Filtration Efficiency | 75% | VTM-51 |
| Flow Rate | 10 gal/min/ft$^2$ | ASTM-D4491 |
| Height | 36 inches | |

C. Posts for silt fence shall be steel and shall have the following properties:

| | |
|---|---|
| ASTM Designation: | ASTM A702 |
| Length: | 5-Feet Long (T-Type) |
| Weight: | 1.33#/Foot (min.) |
| Area of Anchor Plate: | 14 Sq. In. |

Note: Five (T) Fasteners shall be furnished with each post.

D. Wire Fabric for the silt fence shall have the following properties:

| | |
|---|---|
| Wire Fabric Designation: | 832-12-10-12.5 Class 1 |
| Designation: | ASTM A116 |
| Width: | 32" |
| Number of Line Wires: | 6 |
| Stay Wire Spacing: | 6" |
| Line and Stay Wires: | 14 Ga. |
| Top and Bottom Wires: | 14 Ga. |
| Wire Coating: | ASTM Class 1 Zinc Coating |

Silt Fence shall be installed and maintained in accordance with Part 3 of this Section and the notes on the Drawings and to the satisfaction of the Engineer until the site has been stabilized. The cost of Silt Fence shall include the fabric, posts, wire fabric, excavation and all maintenance and restoration activities required.

2.05 STONE FOR EROSION CONTROL

A. The Contractor shall place Stone for Erosion Control as shown on the Drawings, as specified herein. The Stone for Erosion Control shall be as indicated on the Drawings.

2.06 RIP RAP

A. The Contractor shall place rip rap as shown on the Drawings and as specified in Section 804 of the South Carolina State Highway Department Standard Specifications for Rip Rap and Slope Protection. The stone for rip rap shall consist of field stone or rough unhewn

quarry stone. The stone shall be sound, tough, dense, and resistant to the action of air and water. Neither the width nor thickness of individual stones shall be less than one-third their length. The rip rap shall be as shown on the Drawings.

2.07 GRAVEL AND RIPRAP FILTER BERM BASINS

A. Gravel and riprap filter berm basins shall be constructed as shown on the Drawings and as specified herein. The filter berm basins shall be constructed at the upstream end of all culverts as indicated and maintained in accordance with Part 3 of this Section and on the Drawings to the satisfaction of the Engineer until the site has been stabilized. The cost of the filter berms shall include the excavation, grading, stone for erosion control, riprap, etc. and all maintenance activities required.

2.08 TEMPORARY EROSION CONTROL LINING (RECM)

A. The Contractor shall place straw with net, curled wood, coconut fiber rolled erosion control matting (RECM) in areas indicated on the Drawings. Straw with net matting shall consist of clean wheat straw from agricultural crops made into a knitted straw mat that is machine assembled. The straw shall be evenly distributed throughout the mat. The straw with net mat shall be covered with a photodegradable synthetic mesh attached to the straw with degradable thread. The curled wood or coconut fiber mat shall consist of machine-produced mat of curled wood excelsior or coconut fiber with a majority of the fibers 6 inches or longer with consistent thickness and the fibers evenly distributed over the entire area of the mat. The top of the mat shall be covered with a biodegradable synthetic mesh. The mesh shall be attached to the curled wood excelsior or coconut fiber with photodegradable synthetic yarn.

B. The Contractor shall place the straw with net temporary channel and slope RECM where directed immediately after the channel or slope has been properly graded and prepared, fertilized, and seeded. If the mat is of single net construction, the netting shall be on top with the straw in contact with the soil.

C. The Contractor will immediately repair or replaced any section of temporary channel and slope RECM which is not functioning properly or has been damaged in any way until a stable growth of grass has been established.

D. Straw with net RECM shall be as manufactured by North American Green, American Excelsior, Contech, or equal with a minimum bare soil shear stress value as indicated on drawings.

2.09 PERMANENT EROSION CONTROL TURF REINFORCEMENT MAT (TRM)

A. The Contractor shall place synthetic channel and slope TRM in channel or on slopes as shown on the Drawings. The mat shall consist of entangled nylon, polypropylene or polyester monofilaments mechanically joined at their intersections forming a three dimensional structure. The mat shall be crush-resistant, pliable, water-permeable, and highly resistant to chemical and environmental degradation.

B. The Contractor shall place the synthetic TRM where directed immediately after the channel or slope has been properly graded and prepared.

C. After the TRM has been placed, the area shall be properly fertilized and seeded as specified allowing the fertilizer and seeds to drop through the net.

D. The Contractor will immediately repair or replace any section of TRM which is not functioning properly or has been damaged in any way until a stable growth of grass has been established.

E. Synthetic TRM shall be as manufactured by Colbond Geosynthetics, Synthetic Industries, TC Mirafi, or equal matting with a minimum long-term unvegetated shear stress value as indicated on drawings.

2.11 TEMPORARY SLOPE DRAINS

A. Temporary slope drains shall be constructed as shown on the Drawings and as specified herein. The temporary slope drains shall be constructed and maintained in accordance with Part 3 of this Section and the notes on the Drawings to the satisfaction of the Engineer until the site has been stabilized. The cost of the temporary slope drains shall include the piping, earthwork, stone for erosion control, and all maintenance activities required.

2.12 GRAVEL CONSTRUCTION ENTRANCES

A. Gravel Construction Entrances shall be constructed as shown on the Drawings and as specified herein. Temporary gravel construction entrances shall be maintained in accordance with Part 3 of this Section and the notes on the Drawings to the satisfaction of the Engineer until the site has been stabilized. The cost of temporary gravel construction entrances shall include the gravel and all maintenance activities required.

2.13 TEMPORARY SOIL STABILIZER

A. The temporary agent for soil erosion control shall consist of an especially prepared highly concentrated powder which, when mixed with water, forms a thick liquid such as "Enviroseal 2001" by Enviroseal Corporation, "Terra Control" by Quattro Environmental, Inc., or "CHEM-CRETE ECO-110" by International CHEM-CRETE Corporation, and having no growth or germination inhibiting factors. The agent shall be used for hydroseeding grass seed in combination with other approved amendments resulting in a highly viscous slurry which, when sprayed directly on the soil, forms a gelatinous crust.

PART 3 -- EXECUTION

3.01 INSTALLATION AND MAINTENANCE

A. Erosion and sedimentation control devices shall be established prior to or concurrent with the clearing operations in a given area. Where such practice is not feasible, the erosion and sedimentation control device(s) shall be established immediately following completion of the clearing operation.

B. The Contractor shall furnish the labor, materials and equipment required for routine maintenance of all erosion and sedimentation control devices. Maintenance shall be scheduled as required for a particular device to maintain the removal efficiency and intent of the device. Maintenance shall include but not be limited to 1) the removal and satisfactory disposal of accumulated sediment from traps or silt barriers and 2) replacement of filter fabrics used for silt fences and stone used in temporary sediment traps, stone filters, gravel construction entrances, etc.. Sediment removed from erosion and sedimentation control devices shall be disposed of in locations that will not result in off site sedimentation as acceptable to the Engineer, at no additional cost to the Owner.

C. The Contractor shall provide temporary sedimentation traps at all locations shown on the Contract Drawings and for the settling of water pumped from the excavations or intercepted by drainage ditches for keeping water out of the excavations or to protect existing structures. The Contractor shall remove accumulated sediment from the traps as necessary to maintain their effectiveness or as indicated by the Engineer. Sediment material removed from the traps shall be disposed by the Contractor in locations that will not result in off-site sedimentation as acceptable to the Engineer, at no additional cost to the Owner.

1. Inspect temporary sediment traps after each period of significant rainfall. Remove sediment and restore the trap to its original dimensions when the sediment has accumulated to one-half the design depth of the trap. Place the sediment that is removed in a designated disposal area and replace the contaminated part of the gravel facing.

2. Check the structure for damage from erosion or piping. Periodically check the depth of the spillway to ensure it is a minimum of 1.5 ft. below the low point of the embankment. Immediately fill any settlement of the embankment to slightly above design grade. **Any riprap displaced from the spillway must be replaced immediately.**

3. After all sediment-producing areas have been permanently stabilized, remove the structure and all unstable sediment. Smooth the area to blend with the adjoining areas and stabilize properly.

D. The Contractor shall provide temporary diversions at all locations noted on the Contract Drawings. All temporary diversions shall outlet at a temporary sediment trap or other appropriate structure.

1. Inspect temporary diversions once a week and after every rainfall. Immediately remove sediment form the flow area and repair the diversion ridge. Carefully check outlets and make timely repairs as needed. When the area protected is permanently stabilized, remove the ridge and the channel to blend with the natural ground level and appropriately stabilize it.

E. Reinforced silt fence shall be erected as shown on the Drawings and specified herein. Reinforced silt fence shall be erected and maintained to the satisfaction of the Engineer until a vegetative ground cover has been established. Replacement of the filter fabric, if required by the Engineer, will be at the Contractor's expense.

1. Reinforced silt fence shall be erected around all catch basins which are located downstream from any construction work. Should any catch basins be indicated to be relocated or modified, silt fence shall be utilized until work is completed on the catch basins. Upon completion of the modification, the area shall be rough graded, as shown on the Drawings, until the end of the project, at which time final grading shall occur.

2. Inspect silt fence at least once a week and after each rainfall. Make any required repairs immediately.

3. Should the fabric of a silt fence collapse, tear, decompose or become in-effective, replace it promptly.

4. Remove sediment deposits as necessary to provide adequate storage volume for the next rain and to reduce pressure on the fence. Take care to avoid undermining the fence during cleanout.

5. Remove all fencing materials and unstable sediment deposits and bring the area to grade and stabilize it after the contributing drainage area has been properly stabilized. Removal of any silt fence shall be permitted only with the prior approval of the Engineer, or the local governing agency.

F. Riprap shall be graded so that the smaller stones are uniformly distributed through the mass. The Contractor may place the stone by mechanical methods, augmented by hand placing where necessary or ordered by the Engineer. The placed riprap shall form a properly graded, dense, neat layer of stone. The placed riprap shall have a minimum depth of 24 inches. Type II Separator Geotextile shall be used under all riprap unless otherwise noted.

G. Riprap and stone for erosion control shall be dumped and placed in such manner that the larger rock fragments are uniformly distributed throughout the rock mass and the smaller fragments fill the voids between the larger fragments. Rearranging of individual stones by equipment or by hand shall only be required to the extent necessary to secure the results specified above, to protect structures from damage when rock material is placed against the structures, or to protect the underlying Separator Geotextile from damage during installation.

H. The Contractor shall provide gravel and riprap filter berm basins at all locations noted on the Contract Drawings.

1. Inspect gravel and riprap filter berm basins after each period of significant rainfall. Remove sediment and restore the basin to its original dimensions when the sediment has accumulated to one-half the design depth of the trap. Place the sediment that is removed in a designated disposal area and replace the contaminated part of the gravel facing.

2. Check the structure for damage from erosion or piping. **Any stone or riprap displaced from the berm must be replaced immediately.**

3. After all sediment-producing areas have been permanently stabilized, remove the structure and all unstable sediment. Smooth the area to blend with the adjoining areas and stabilize properly.

I. Engineer may direct the Contractor to place Straw with Net, Curled Wood or Coconut Fiber RECM's and Synthetic TRM's in permanent channels or on slopes at other locations not shown on Drawings.

1. All temporary and permanent channel and slope lining RECM's and TRM's shall be unrolled in the ditch in the direction of the flow of water. Temporary linings shall overlap the buried end of the downstream blanket by a minimum of 6 inches. Permanent linings shall overlap a minimum of 3 feet. All anchor and transverse trenches shall be a minimum of 12 inches deep. All mat shall be stapled as per manufacturer's specifications.

2. During the establishment period, check grass, RECM and TRM-lined channels after every rainfall event. For grass-lined channel once grass is established, check periodically and after every heavy rainfall event. Immediately make repairs. It is particularly important to check the channel outlet and all road crossings for bank stability and evidence of piping and scour holes. Give special attention to the outlet and inlet sections and other points where concentrated flow enters. Remove all significant sediment accumulations to maintain the designed carrying capacity. Keep the grass in a healthy, vigorous condition at all times.

J. The Contractor shall provide temporary slope drains at all location noted on the Contract Drawings, and at other locations as may be directed by the Engineer.

1. Inspect the temporary slope drain and supporting diversion after every rainfall event and promptly make any necessary repairs. When the protected area has been permanently stabilized, temporary measures may be removed, materials disposed of properly, and all disturbed areas stabilized appropriately.

K. The Contractor shall provide temporary gravel construction entrances at all locations noted on the Contract Drawings, and at all other locations as may be directed by the Engineer.

1. Maintain the gravel pad in a condition to prevent mud or sediment from leaving the construction site. This may require periodic topdressing with 2-inch stone. After each rainfall, inspect each construction entrance and clean out as necessary. Immediately remove all objectionable materials spilled, washed, or tracked onto public roadways.

L. The Contractor shall provide temporary or permanent ground cover adequate to restrain erosion on all disturbed areas that will be left unworked for periods exceeding 15 working or 30 calendar days.

1. Reseed and mulch temporary seeding areas where seedling emergence is poor, or where erosion occurs, as soon as possible. Do not mow. Protect from traffic as much as possible.

2. Generally, a stand of vegetation cannot be determined to be fully established until soil cover has been maintained for one full year from planting. Inspect seeded areas for failure and make necessary repairs and reseedings within the same season, if possible.

3. **Reseeding –** If a stand has inadequate cover, re-evaluate choice of plant materials and quantities of lime and fertilizer. Re-establish the stand after seedbed preparation or over-seed the stand. Consider seeding temporary, annual species if the time of year is not appropriate for permanent seeding.

4. If vegetation fails to grow, soil must be tested to determine if acidity or nutrient imbalance is responsible.

5. **Fertilization –** On the typical disturbed site, full establishment usually requires refertilization in the second growing season. Fine turf requires annual maintenance fertilization (See Table 6.12b, ESCPDM). Use soil tests if possible or follow the guidelines given for the specific seeding mixture (See Tables 6.11c through 6.11v, ESCPDM)

M. Additional Requirements

1. All storm sewer piping shall be blocked at the end of every working day until the inlet is constructed above grade.

2. All streets around the construction area shall be scraped as necessary to prevent accumulation of dirt and debris.

3. The Contractor shall provide adequate means to prevent any sediment from entering any storm drains, curb inlets (curb inlet filter box), ditches, streams, or bodies of water downstream of any area disturbed by construction. Excavation materials shall be placed upstream of any trench or other excavation to prevent sedimentation of offsite areas. In areas where a natural buffer area exists between the work area and the closest stream or water course, this area shall not be disturbed.

4. The Engineer may direct the Contractor to place any additional sediment and erosion control devices at other locations not shown on the Drawings.

5. Contractor shall also adhere to all requirements indicated in the notes for each erosion control detail on the Drawings.

3.02 INSPECTIONS AND MAINTENANCE

A. The Contractor shall designate a Qualified Person to perform inspections required by this Section. The following areas are to be inspected and maintenance performed, if needed, at least once every 7 calendar days and within 24 hours of a rainfall event that has a precipitation of 1/2 inch or greater.

1. Disturbed areas of the construction site that have not undergone final stabilization

2. Erosion and sediment control structures

3. All locations where vehicles enter or exit the site

4. Material storage and construction laydown areas that are exposed to precipitation and have not been finally stabilized

B. Immediate action will be taken to correct deficiencies to BMP's. The State reserves the right to stop all construction activities not related to maintaining BMP's until such deficiencies are repaired.

C. In areas that have been finally stabilized, inspections and, if necessary, maintenance by Contractor will occur at least once per month for the duration of the contract or project, whichever is longer.

D. During inspections the following will be observed and appropriate maintenance procedures taken:

1. The conformance to specifications and current condition of all erosion and sediment control structures

2. The effectiveness and operational success of all erosion and sediment control measures

3. The presence of sediments or other pollutants in storm water runoff at all runoff discharge points

4. If reasonably accessible, the presence of sediments or other pollutants in receiving waters

5. Evidence of off-site tracking at all locations where vehicles enter or exit the site

E. An inspection checklist must be completed during each inspection, dated, and signed by the Qualified Person conducting the inspection. Completed inspection checklist shall be kept on-site with the Contract Documents and submitted to the Engineer on a monthly basis. The Contractor will repair deficiencies within 24 hours of inspection.

## 3.03 REMOVAL OF TEMPORARY SEDIMENT CONTROL STRUCTURES

A. At such time that temporary erosion and control structures are no longer required under this item, the Contractor shall notify the Engineer of its intent and schedule for the removal of the temporary structures, and obtain the Engineer's approval in writing prior to removal. Once the Contractor has received such written approval from the Engineer, the Contractor shall remove, as approved, the temporary structures and all sediments accumulated at the removed structure shall be returned upgrade. In areas where temporary control structures are removed, the site shall be left in a condition that will restore original drainage. Such

areas shall be evenly graded and seeded as specified in Section 02910 - Final Grading and Landscaping.

- END OF SECTION -

SECTION 02340

BORED CROSSINGS

PART 1 -- GENERAL

1.01. SCOPE OF WORK

A. Furnish all labor, equipment, materials, and incidentals required and install casing pipe by trenchless hydraulic jacking within the limits of work as defined on the Contract Drawings. The work shall be done in accordance with all Federal, State, and local laws, regulations and requirements as shown on the Drawings and as specified herein.

B. The work, as detailed on the Drawings and described in these Specifications, shall include, but not be limited to, the following:

1. trenchless construction of casing and carrier pipe across State, Federal, Railroad, and Private Transportation Corridors or across other structures, utilities, waterways, or environmentally sensitive areas as indicated on drawings,
2. pipe jacking by track type boring machine or hydraulic jacking frame,
3. casing/tunnel excavation,
4. disposal of casing/tunnel spoil,
5. supplying and installing casing/jacking pipe as initial support,
6. carrier pipe,
7. casing seals,
8. filling of voids between casing/jacking pipe and earth,
9. filling annular void between casing and carrier pipe,
10. design and construction of launch and receiving pits,
11. dewatering at the pits,
12. dewatering of the tunnel (if allowed),
13. appropriate disposal of groundwater effluent, and
14. location markers and miscellaneous appurtenances as required to complete the installation.

C. The work shall also include: furnishing, installing, monitoring by survey, reducing, plotting, reporting that same survey data to the engineer and maintaining and protecting all the instrumentation on buildings, utilities, rails and in the ground adjacent to the site or on the site and as necessary to monitor construction performance and impacts on adjacent property

D. Boring/tunneling activities shall not cause any damage to nearby structures, railroad tracks, utilities and pavement.

E. The Contractor shall be familiar with the conditions under which the work will be performed and with all necessary details as to the orderly prosecution of the work. Review and

interpret available geotechnical reports and investigate work site soil conditions before bidding.

F. For all excavations defined herein Contractor shall install casing/jacking pipe using techniques and methods selected by the Contractor that are appropriate for prevailing ground conditions. Contractor selected tunneling installation techniques and methods of construction shall include all equipment, all associated support systems and their operation, ground modification where needed, lubrication to reduce jacking forces as needed, cutting face tooling and sizing, face access capabilities, and the use of engineered fluids, slurries, and soil conditioners as required to maintain face stability, reduce wear, advance heading within line and grade tolerances, transport spoils, and accomplish productivity assumed in Contractor's bid proposal.

G. If any movement or settlement occurs which causes or might cause damage to an existing structure or railroad track over, along or adjacent to the work, immediately stop any or all work except that which assists in making the work secure and in preventing further movement, settlement or damage. Resume boring/tunneling only after all necessary precautions have been taken to prevent further movement, settlement or damage, and repair the damage at the Contractor's own cost and to the satisfaction of the Engineer.

H. Follow all OSHA regulations regarding confined space for casing installation.

I. Conform with all SC Department of Transportation and Federal Highway Administration requirements for work within restricted access highway rights-of-way and any additional requirements of the contiguous property and utility owners.

J. Rescue shafts are not allowed.

K. Direct jacking of carrier pipe is prohibited.

L. The Contractor shall retain the service of a professional engineer registered in the State of South Carolina to prepare boring/tunneling design and submittals described herein.

M. Boring/Tunneling operations will be on a continuous basis, 24 hours per day, 7 days a week. The Contractor shall furnish the names of all subcontractors which he proposes to use for this work including necessary evidence and/or experience records. The Contractor or subcontractor performing the boring and jacking construction shall have a minimum of five (5) years experience in boring and jacking casing pipe on similar projects of similar pipe diameters and lengths.

1.02. REFERENCE STANDARDS

A. The highway/railroad crossing(s) shall comply with standards and best practices set forth in the following:

1. "Standard Specifications for Highway Construction" from the S.C. Department of Transportation (Latest Revision),
2. All best practices and requirements of any and all right-of-way encroachment agreements, occupancy permits or other established requirements and specifications of the entity being crossed.
3. "Utility Accommodations Policy" from the S.C. Department of Transportation (Latest Revision),

4. "Standard Specifications for Pipelines Conveying Flammable and Non-Flammable Substances" from the American Railway Engineering Association, and the "Standard Specifications for Highway Bridges" from AASHTO (Latest Revision).

B. The materials covered by these Specifications are intended to be standard materials of proven reliability and as manufactured by reputable manufacturers having experience in the production of such materials. The materials furnished shall be designed, constructed, and installed in accordance with the best practices and methods.



1.03. RELATED WORK SPECIFIED ELSEWHERE

A. Division 2 - Sitework

1.04. SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Requirements and Division 1, the Contractor shall submit the following:

1. Casing/Jacking pipe shop drawings and material data from casing pipe manufacturer.

2. Bore pit excavation details including footprint drawing of bore pit, design and calculations for any sheeting or shoring utilized signed and sealed by a professional engineer registered in the State of South Carolina.

3. Construction sequence plan including drilling, casing, and grouting placement procedures.

4. Casing spacer manufacturer's data and shop drawings.

5. Experience qualifications of contractor or subcontractor.

6. Proposed grout and pumping system.

PART 2 -- MATERIALS

2.01 STEEL CASING PIPE

A. Carbon steel casing pipe exterior diameter shall be as indicated on the Drawings or shall, in all cases, be great enough to afford easy removal of the carrier pipe without disturbing the casing pipe or roadbed. The casing pipe shall be smooth wall or spiral welded steel pipe. Casing pipe shall be leak-proof construction and be capable of withstanding highway or railroad loadings where applicable. Casing pipe shall be steel pipe in sizes 12-inches and larger manufactured from steel having a minimum yield stress strength of 35,000 psi and shall have a minimum wall thickness as indicated on the Contract Drawings.

B. All joints shall be butt welded with a full depth, single "V" groove weld. Machined, interlocking, press-fit joints such as made by Permalok Corporation of St. Louis or equal may be substituted if written acceptance has been provided in by all property owners and permitting authorities associated with crossing.

C. The casing pipe shall conform to ASTM A 139, Grade B (without hydro-test) or ASTM A53, Grade B (without hydro-test), and AWWA C200-75.

D. Upon completion of carrier pipe installation for the SCDOT roadway bores only, annular space between casing and carrier pipe shall be filled with grout and sealed at each end with a masonry wall. Annular space between casing and carrier pipe for railroad bore shall not be filled, but shall be sealed at each end with a masonry wall.

2.02 TUNNEL LINER PLATE – (NOT ALLOWED)

2.03 REINFORCED FIBERGLASS JACKING PIPE AS CASING – (NOT ALLOWED)

2.04 REINFORCED CONCRETE JACKING PIPE AS CASING – (NOT ALLOWED)

2.05 VETRIFIED CLAY JACKING PIPE AS CASING – (NOT ALLOWED)

2.06 CARRIER PIPE

A. The carrier pipe shall be ductile iron restrained joint pipe as specified or as shown on the Contract Drawings.

2.07 GROUT

A. Grout for pressure injection between the casing and the earth shall be a mixture of Portland cement and bentonite or similar commercial product that shall harden to a minimum compressive strength of 100 psi attained within 24 hours. The grout shall be readily pumpable. The shop drawings shall include both the proposed grout and the pumping system.

B. Cement grout used to fill the space between the casing and the carrier pipes shall consist of a mixture of about 1 part cement to 6 parts sand which shall be subject to increase or decrease in the amount of cement necessary to provide good flowing characteristics. Cement grout shall have a minimum pH of 12 and shall be free of fly ash.

2.08 CASING SPACERS

A. Contractor shall properly install and prevent the carrier pipe from floating by the use of casing spacers. Casing spacers shall be stainless steel, carbon steel or high-density polyethylene. The model of casing spacers shall correspond to the diameter of the carrier pipe and encasement pipe. Casing spacers shall fasten tightly onto the carrier pipe so that when the carrier pipe is being installed, the spacers will not move along the carrier pipe. Casing spacer placement along the carrier pipe shall be in accordance with the manufacturer's recommendations. Maximum distance between casing spacer and internal wall of casing pipe shall be 2-inches. The proposed procedure to install the carrier pipe is to "bell-up" the pipe outside the casing and push the carrier pipe through the casing. Casing spacers shall be manufactured by Advance Products and Systems, Cascade Waterworks Mfg. Co., Pipeline Seal and Insulator, Public Works Marketing, or approved equal.

2.09 CONCRETE CRADLE

A. Concrete cradles shall be installed at the low end of each bore and jack as indicated in the details on the Contract Drawings. Cradle shall be roughly formed around the pipe so as to provide a smooth bearing surface. Concrete cradles shall be constructed of Class B concrete.

2.10 LAUNCH AND RECEIVING PITS

A. Bore pits shall be excavated and backfilled in accordance with Section 02220 (Trenching, Backfilling, and Compacting for Utilities) and meet all federal and state OSHA requirements for a safe excavation. Bore pits shall be located so as to not undermine roadway pavements or railroad tracks and ballast. Excavation supports and temporary sheeting/bracing shall be utilized as necessary.

2.07 MASONRY WALL

A. One (1) course of standard brick and mortar masonry wall shall be constructed at each end of casing pipe, flush with casing pipe opening, once carrier pipe is installed. Brick shall have a nominal size 2-1/4 inches by 3-3/4 inch by 8 inch. Mortar shall be one part Portland cement blended with three parts sand (100% passing #4 sieve and minimum 95% passing No. 8 sieve) and have a minimum 7-day compressive strength of 500 psi. Prepared bag mixes are acceptable if approved by the Engineer.

PART 3 -- EXECUTION

3.01 INSTALLATION - GENERAL

A. The Contractor shall be responsible for the design, adequacy and methodology of the trenchless installed casing pipe. The Contractor shall submit the proposed method of installation, detailed layout information, methods to be implemented if unusual or adverse soil conditions (i.e.: running sand, water, etc.) are encountered during installation. Design certifications for installation method shall be sealed and signed by a professional engineer registered in the State of South Carolina to the Engineer for submittal to the S.C. Department of Transportation prior to starting work.

B. The Contractor shall be responsible for selection of tunneling equipment which, based on past experience, has proven to be satisfactory for excavation of the soils to be encountered.

C. If a combination of casing and tunnel is required, details of the proposed junction shall be submitted to and approved by the SCDOT, or the affected Railroad Company, and the Engineer.

D. Encountering rock or water will not entitle Contractor to additional compensation.

E. Notify Engineer immediately if obstruction stopping forward motion of operation is encountered during installation.

F. When impossible to advance bore hole or pipe, discontinue operation, abandon completed portion in place, and fill with grout or plug, unless otherwise directed by SC Department of Transportation, or the affected Railroad company, or Engineer.

G. Dewatering: When water is encountered, develop and maintain dewatering system of sufficient capacity to remove water continuously, keeping excavations free of water until backfill operation is in progress.

H. Keep removal of soils particles to minimum.

I. Dewater into sediment trap following Specification.

J. Observe settlement or displacement of surface facilities due to dewatering.

K. Should settlement or displacement be detected, notify Engineer immediately and act to maintain safe conditions and prevent damage.

L. The recommended methods and details shown on the Drawings and specified herein, are intended to indicate the minimum acceptable standard of quality required for the casing/tunnel installation. Other methods of installation, based on acceptable industry standards and techniques, may be acceptable for the installation. Under no conditions shall jetting or wet boring of the casing/tunnel be allowed.

M. All excavations and pits shall be well sheeted and braced as necessary for safe and adequate access for workmen, inspections, and materials and shall be of a size suitable to equipment and material handling requirements.

N. All of the Contractors plans, specifications and design computations for pit shoring shall be sealed and signed by a Professional Engineer registered in the State of South Carolina. Trench box temporary shoring for boring pits shall not be allowed.

O. All pits required for the installation of the casing/tunnel and located within SCDOT right-of-way shall be completely isolated from the roadway traffic with precast concrete barriers installed in accordance with the SCDOT Roadway Standard Drawings, or details.

3.02 BORING AND JACKING

A. As the boring operation progresses, each new section of the casing pipe shall be 360° butt-welded, using a full depth, single "V" groove weld, to the next section previously jacked into place unless special interlocking joints are allowed.

B. The boring equipment to be used for installing the jacked casing shall be of such size and capacity to allow the boring to proceed in a safe and expeditious manner. The installation of the casing and boring of the hole shall be done as rapidly as possible and shall be done simultaneously to avoid voids, cave-ins or settlement and for safety of traffic above.

C. A special lubricant may be used to facilitate movement or lessen the danger of jacked pipe from freezing.

D. Maintain face of cutting head to preclude free flow of soft or poor soils material.

E. The Contractor shall employ tunneling equipment that will be capable of handling the various anticipated ground conditions and is capable of minimizing loss of soil ahead of and around the machine and shall provide satisfactory support of the excavated face. The

Contractor shall be prepared to bore through all types of rock, if encountered, with a specialized bit or hand mine. All bored crossings on this project shall be guaranteed.

F. If voids are encountered or occur outside the casing pipe, grout holes shall be installed in the top section of the casing pipe at 4 foot (maximum) centers and the voids filled with 1:3 Portland Cement to sand grout with sufficient water added to produce a flowable mixture and at sufficient pressure to prevent settlement. The Contractor shall be prepared to bore through weathered or partially weathered rock, if encountered, with a specialized bit or hand-mine. Costs associated with this provision shall be deemed as included in the Unit Price Bid for each location and no additional payment will be made.

G. In the event an obstruction is encountered during the boring and jacking operation, and the casing pipe is at least 30-inches in diameter, the auger shall be withdrawn and the obstruction removed. If a bolder is encountered and is removed by blasting or other approved method, the void shall be filled with grout, as previously specified. No blasting shall be permitted until a detailed blasting plan is submitted to and approved by the SCDOT, or the affected Railroad Company, and the Engineer.

3.03 CONSTRUCTING TUNNEL LINER IN PLACE FOLLOWING ADVANCE OF LEADING EXCAVATION – (NOT USED)

3.04 CASING/TUNNEL ALIGNMENT

A. Contractor shall select and use proper equipment selection and operation including advanced line and grade control systems to meet the horizontal and vertical alignment requirements of the project as identified on the Contract Drawings and specified in the Contract. Constructor shall determine the need for and select systems and methods for achieving the adequate line and grade control appropriate for the ground conditions and constraints of the project including:

1. water-level grade monitoring or laser-level line and grade monitoring systems,

2. methods for tracking location of cutter head such as sonde receivers, or other systems,

3. pilot tube pre-drilling to set and maintain alignment as necessary to meet Contract Documents, and

4. articulated, steerable cutterhead or other hydraulically actuated steering system.

B. Contractor shall increase casing diameter, at no additional cost to the owner, as necessary to provide additional internal tolerance to account for all project site and subsurface conditions and line and grade accuracy of the construction methods and operation to ensure final gravity sewer carrier pipe can be installed to the line and grade requirements of the Contract Documents. If Contractor elects to modify casing diameter from sizing shown on the Contract Documents, the Contractor accepts all responsibility for acquiring approval for any modification or addenda to all right-of-way encroachment agreements, occupancy permits or other established requirements and specifications of the entity being crossed.

C. The Contractor shall check the vertical and horizontal alignment of the casing/tunnel by survey instrument in spacing intervals as deemed appropriate by the Contractor to meet the line and grade requirements and subsurface conditions of the project. At no time, shall

intervals between vertical and horizontal alignment checks exceed the minimum one horizontal and one vertical check for each four feet of advance.

D. If excavated alignment is found to be off line or grade, make alignment corrections to the installation of the casing as needed to avoid the potential for reverse grades for the final carrier pipe.

E. Acceptance criteria tolerances for the sewer carrier pipe shall be plus or minus 18 inches in horizontal alignment from the Contract Drawings across the entire length of the project. At no point should the slope be less than 0.058 feet per 100 feet of pipe while maintaining positive flow between the tie-in elevations shown on the contract drawings. The tie-in elevations should be as shown on the Contract Drawings. If modifications are necessary to the junction vaults as a result of exceeding the tolerances, they shall be done at no additional cost to the Owner.

F. Pipe installed outside tolerances and subsequently abandoned shall first be fully grouted.

3.05 CARRIER PIPE CRADLE INSTALLATION

A. Following completion of the tunnel excavation and grouting operations, a concrete pipe cradle shall be formed and poured as shown on the Drawings. The forms shall be constructed of wood, poured into place with concrete at a spacing adequate to support the carrier pipe. The forms shall be placed such that they produce a true cradling channel whereby the pipe shall be skidded into place on its required alignment and grade. In lieu of the wood cradle, adequately designed and spaced pipe alignment guides (spiders) may be used to slide the pipe along the concrete pipe cradle. The concrete pipe cradle can be eliminated when using a casing pipe with pipe alignment guides.

3.06 CARRIER PIPE INSTALLATION

A. For all casing installations, the carrier pipe shall be installed with adequately designed and spaced pipe alignment guides "spiders", secured, and bulkheaded as shown on the Drawings. The proposed procedure to install the carrier pipe is to "bell-up" the pipe outside the casing and push the carrier pipe through the casing.

B. Concrete brick and mortar bulkheads with air and water vent holes shall be constructed at the terminal ends of the casing/tunnel.

C. In addition, a Class B concrete cradle shall be provided from the end of the casing/tunnel bulkhead to the first pipe joint outside the casing/tunnel.

3.07 SURFACE SETTLEMENT MONITORING

A. Prior to the beginning of any casing/tunnel excavation, a surface settlement monitoring grid system shall be installed on the highway/railroad. This grid shall consist of PK nails installed along the tunnel centerline at ten foot intervals. Additional lines of PK nails shall be installed ten feet each side of the centerline. These points shall be initially read and the elevations recorded prior to the start of the casing/tunnel construction. If no visible settlement is occurring during casing/tunnel excavations, these points shall be read only at such times as the Contractor's surveyor is present to transfer the line and grade into the

casing/tunnel. These points shall be checked and elevations recorded on a daily basis, until the casing/tunnel installation is completed.

3.08 SPECIAL CONSTRUCTION REQUIREMENTS FOR EXISTING EASEMENTS AND RIGHTS OF WAY

A. Refer to Section 00900 (Special Provisions) for specific SCDOT and Railroad Agency encroachment and occupancy requirements.

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SECTION 02510

PAVING AND SURFACING

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish all labor, equipment and materials and perform all operations in connection with the construction of asphalt concrete pavement, asphalt concrete overlay, reinforced concrete pavement, gravel roads, concrete curb and gutter, repair and reconstruction of existing asphalt concrete pavement, repair of existing gravel roads, and pavement markings complete as specified herein and as detailed on the Drawings.

B. All new roads including the replacement of portions of the existing roads shall be to the limits, grades, thicknesses and types as shown on the Drawings. Patches for pipe crossings and areas damaged during the construction work shall be asphalt and/or gravel, depending upon the material encountered, unless otherwise indicated.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Requirements of related work are included in Division 1, Division 2 and Division 3 of these Specifications.

1.03 RELATED SECTIONS

A. Section 02200 - Earthwork

B. Section 03300 - Cast-In-Place Concrete

1.04 STANDARD SPECIFICATIONS

A. Except as otherwise provided in the Specifications or on the plans, all work shall be in accordance with the South Carolina Department of Transportation Standard Specifications for Highway Construction except that any reference to "SCDOT", "Department" or "Unit" shall mean the "Owner". When reference to these Specifications is intended, the description will be SCDOT Section _____ or SCDOT Specifications.

B. Except with the approval of the Engineer, the placing of concrete or asphalt concrete surface paving shall be subject to the Seasonal and Weather Restrictions set forth in SCDOT Specifications.

PART 2 -- MATERIALS

2.01 SELECT FILL

A. The Contractor shall place select fill as necessary to complete the embankments, shoulders, subgrade foundation and replacement for removed unsuitable material in accordance with SCDOT Section 205, and Section 02200, Earthwork

2.02 CEMENT STABILIZED AGGREGATE BASE

A. All work, including materials, associated with Cement Stabilized Aggregate Base shall be in accordance with SCDOT Section 308, Cement Stabilized Aggregate Base, except that Articles 308.5 and 308.6, shall be deleted.

2.03 HOT MIX ASPHALT (HMA) PAVEMENT

A. All work, including materials, associated with Hot Mix Asphalt Pavement shall be in accordance with Section 401, Hot Mix Asphalt (HMA) Pavement, of the SCDOT Standard Specifications, except Articles 401.5 and 401.6 shall be deleted. A job mix formula will be developed by the Contractor for the particular materials the Contractor proposes to use.

B. The job mix formula shall be delivered to the Engineer at least two (2) weeks prior to beginning paving operations.

2.04 HMA INTERMEDIATE COURSE

A. All work, including materials, associated with HMA Intermediate Course shall be in accordance with Section 402, HMA Intermediate Course, of the SCDOT Standard Specifications, except Articles 402.5 and 402.6 shall deleted. A job mix formula will be developed by the Contractor for the particular materials the Contractor proposes to use.

B. The job mix formulas shall be delivered to the Engineer at least two (2) weeks prior to beginning paving operations.

2.05 HMA SURFACE COURSE

A. All work, including materials, associated with HMA Surface Course shall be in accordance with Section 403, HMA Surface Course, of the SCDOT Standard Specifications, except Articles 403.5 and 403.6 shall be deleted. A job mix formula will be developed by the Contractor for the particular materials the Contractor proposes to use.

B. The job mix formulas shall be delivered to the Engineer at least two (2) weeks prior to beginning paving operations.

2.06 PORTLAND CEMENT CONCRETE PAVEMENT

A. All work, including materials associated with rigid concrete pavement shall be in accordance with Section 03300, Cast-In-Place Concrete. Class A1 concrete shall be used. Placement shall be in accordance with Section 03300 and SCDOT Section 501, except that Articles 501.5 and 501.6 shall be deleted.

2.07 PORTLAND CEMENT CONCRETE PAVEMENT REINFORCING

A. Reinforcing, if specified, shall be as shown on the Structural Drawings and as specified under Section 03200, Reinforcing Steel.

2.08 CONCRETE CURB AND GUTTERS

A. Concrete shall be Class B in accordance with the requirements of Section 03300, Cast-In-Place Concrete, except that concrete shall be air-entrained to provide an air content of 6% ± 1.5%.

B. Premolded expansion joint filler for expansion joints shall conform to ASTM D 1751 and shall be 1/2-inch thick, minimum.

PART 3 -- EXECUTION

3.01 EMBANKMENT

A. The embankment shall be constructed in accordance with Section 02200, Earthwork.

3.02 SUBGRADE

A. The subgrade, where shown on the Drawings, shall be aggregate stabilized by the addition and mixing of coarse aggregate with the top 3-inches of subgrade. Following the application, the subgrade shall be formed true to crown and grade, and shall be compacted with a minimum of four (4) passes of a 15-ton vibratory roller to conform to the maximum densities determined by AASHTO T99 Standard Specifications.

3.03 CEMENT STABILIZED AGGREGATE BASE

A. The finished base course of all paving shall be Cement Stabilized Aggregate Base and shall be of the thickness shown on the Drawings, formed true to crown and grade. Gravel roads, including repair to existing gravel roads shall be Cement Stabilized Aggregate Base and shall be of the thicknesses shown on the Drawings, formed true to crown and grade.

3.04 HMA INTERMEDIATE COURSE

A. HMA Intermediate Course shall be placed in accordance with SCDOT Standard Specifications Sections 401 and 402. HMA Intermediate Course shall be compacted in accordance with SCDOT Standard Specifications. Thicknesses shall be as shown on the Drawings.

3.05 HMA SURFACE COURSE

A. Prior to placement of the HMA surface course, the base/intermediate course shall be inspected for damage or defects and repaired to the satisfaction of the Engineer. The surface of the base/intermediate course shall be approved by the Engineer.

B. The tack coat shall be applied to the surface of the approved base/intermediate course as described in SCDOT Section 401 and 403. Equipment for applying the tack coat shall be power-oriented pressure spraying or distributing equipment suitable for the materials to be applied and approved by the Engineer.

C. The HMA Surface Course shall be placed and compacted on the base/intermediate course in layers not to exceed 2-inches and at the rate of 110-pounds per square yard per inch. Surface Course shall be compacted in accordance with SCDOT Standard Specifications. Thicknesses shall be as shown on the Drawings.

3.06 PORTLAND CEMENT CONCRETE PAVEMENT

A. The subgrade and base course beneath portland cement concrete pavement shall be prepared in accordance with the applicable Sections of these Specifications and referenced Standard Specifications, except that the Contractor shall use an approved automatically controlled fine grading machine to produce final subgrade and base surfaces meeting the lines, grades, and cross sections (thicknesses) shown on the Drawings or established by the Engineer.

B. The surface of the base shall be damp at the time the concrete is placed. The Contractor shall sprinkle the base when necessary to provide a damp surface. The Contractor shall satisfactorily correct all soft areas in the subgrade or base prior to placing concrete.

C. Hauling over the base course shall not be allowed except where specifically permitted by and in writing by the Engineer. The Engineer may allow equipment dumping concrete to operate on the base to the extent and under the conditions the Engineer deems necessary to facilitate placing and spreading the concrete.

D. Installation of the concrete pavement shall be in accordance with the details shown on the Drawings and Division 3 - Concrete. The concrete pavement shall cure a minimum of ten (10) calendar days and until the concrete has attained a minimum flexural strength of 550 psi as indicated by flexural strength testing. The Contractor shall coordinate and pay for all flexural strength testing with a minimum of four (4) 6-inch by 6-inch by 20-inch beams for every fifty (50) cubic yards of pavement concrete installed.

E. Contraction joints shall be spaced at intervals as shown on the Drawings. Transverse contraction joints shall be formed by an approved joint insert. Expansion joints shall be placed when the pavement abuts a structure using 1-inch expansion joint material (filler) and sealant as specified herein.

3.07 CONCRETE CURB AND GUTTER

A. The expansion joint filler for concrete curb and gutters shall be cut to conform to the cross section of the curb. Expansion joints shall be spaced at intervals of not more than 25-feet. Formed control joints shall be installed at intervals not exceeding 10 feet. Depth of joint shall be 1/3 the thickness. Curved forms shall be used where radii are indicated; straight segments shall not be permitted. Upon removal of the forms, exposed curb faces shall be immediately rubbed down to a smooth and uniform surface. No plastering shall be permitted.

3.08 UNDERGROUND UTILITY LINES

A. Where an underground utility line is beneath the new roadway, the backfilling shall be carried out with special care, and the final consolidation shall be accomplished by a vibratory roller. Construction of the roadway over the trench shall be deferred as long as practicable.

3.09 JUNCTION WITH OTHER PAVING

A. Where new HMA pavement abuts existing HMA pavement, the existing pavement shall be cut back to insure obtaining the specified compaction of the new pavement courses and interlocking adjoining courses. Existing subbase courses shall be cut back from the subgrade level of the new pavement on a one-on-one slope into the existing pavement, and the HMA courses of the existing pavement shall be removed for an additional 6-inches back from the slope. The edge of the existing HMA courses shall be saw cut straight and true. The faces between new and existing asphalt courses shall receive an application of tack coat.

B. Where new concrete pavement abuts existing concrete or HMA paving, the existing paving shall be saw cut straight and true. An expansion joint of a 1/2-inch minimum thickness with filler material and sealant shall be placed between the new concrete pavement and the existing concrete or HMA paving.

3.10 HMA OVERLAY

A. Where HMA is proposed to be placed over an existing HMA or concrete surface, the surfaces shall be thoroughly cleaned by power brooming and a tack coat shall be applied in accordance with SCDOT Standard Specifications, prior to installing the overlay. The overlay shall be applied in accordance with Standard Specifications and Standard Details shown on the Drawings.

-END OF SECTION-

SECTION 02520

CONCRETE PAVING

PART 1 -- GENERAL

1.01 SECTION INCLUDES

A. Portland cement concrete paving.

1.02 RELATED SECTIONS

A. Section 02200 - Earthwork.

B. Section 02510 – Paving and Surfacing.

C. Section 02276 – Erosion and Sedimentation Control.

1.03 REFERENCES

A. ACI 211.1 - Selecting Proportions for Normal, Heavyweight, and Mass Concrete.

B. ACI 301 - Specifications for Structural Concrete for Buildings.

C. ACI 302 - Guide for Concrete Floor and Slab Construction.

D. ACI 304 - Recommended Practice for Measuring, Mixing, Transporting and Placing Concrete.

E. ACI 305R - Hot Weather Concreting.

F. ACI 306R - Cold Weather Concreting.

G. ACI 308 - Standard Practice for Curing Concrete.

H. ACI 318 - Building Code Requirements for Reinforced Concrete.

I. ASTM A185 - Welded Steel Wire Fabric for Concrete Reinforcement.

J. ASTM A615 - Deformed and Plain Billet-Steel for Concrete Reinforcement.

K. ASTM C31 - Test Methods of Making and Curing Concrete Test Specimens in the Field.

L. ASTM C33 - Concrete Aggregates.

M. ASTM C39 - Test Method for Compressive Strength of Cylindrical Concrete Specimens.

N. ASTM C94 - Ready Mix Concrete.

O. ASTM C150 - Portland Cement.

P. ASTM C171 - Sheet Materials for Curing Concrete.

Q. ASTM C172 - Practice for Sampling Freshly Mixed Concrete.

R. ASTM C260 - Air-Entraining Admixtures for Concrete.

S. ASTM C330 - Lightweight Aggregates for Structural Concrete.

T. ASTM C494 - Chemical Admixtures for Concrete.

U. ASTM D1751 - Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction.

V. SCDOT (South Carolina Department of Transportation) - SSHC (Standard Specifications for Highway Construction), latest edition.

W. Base course aggregate material shall comply with SCDOT SSHC, Section 306.

1.04 SUBMITTALS FOR REVIEW

A. Section 01300 - Submittals.

B. Product Data: Provide data on joint filler, admixtures, curing compounds.

1.05 QUALITY ASSURANCE

A. Perform work in accordance with ACI 301 and the SCDOT SSHC Sections 500 and 720.

B. Maintain one copy of each document on site.

C. Obtain cementitious materials from same source throughout.

D. Conform to ACI 305R when concreting during hot weather.

E. Conform to ACI 306R when concreting during cold weather.

F. The ready-mix plant utilized shall be SCDOT certified.

G. Storage: Reinforcing shall be kept free from mud.

1.06 ENVIRONMENTAL REQUIREMENTS

A. Do not place concrete when base surface temperature is less than 40 degrees F, or surface is wet or frozen.

PART 2 -- PRODUCTS

2.01 FORM MATERIALS

A. Form Materials: Conform to ACI 301 and as specified in Section 03100.

2.02 REINFORCEMENT

A. Reinforcing Steel: ASTM A615; Grade 60; deformed billet steel bars; unfinished; shop fabricated. Bars shall be of size, cross-section and arrangement as detailed or in accordance with ACI Standard 315 if detailed bending diagrams are not given. Bars with kinks, or bends not shown on the Drawings, shall not be used.

B. Welded Steel Wire Fabric: Plain type, ASTM A185; in flat sheets; unfinished. Welded steel wire fabric shall be of the gauge and size as indicated on the Drawings.

C. Dowels: ASTM A615; Grade 60; plain steel, unfinished.

D. Spacers, chairs, ties and other necessary devices for properly placing the reinforcing shall be provided.

2.03 CONCRETE MATERIALS

A. Cement: ASTM C150, Type I - Normal Portland type.

B. Fine and Coarse Mix Aggregates: ASTM C33. Fine aggregate shall be natural sand. Coarse aggregate shall be gravel or crushed stone. Maximum size of coarse aggregate for normal reinforced sections shall be 3/4 inch, and for heavy plain or lightly reinforced section shall be 1-1/2 inch.

C. Water: Potable.

D. Air Entrainment: ASTM C260.

E. Chemical Admixture: ASTM C494 Type D - Water Reducing and Retarding. Shall not be used except with the written consent of the Engineer.

2.04 ACCESSORIES

A. Curing Compound: In accordance with SCDOT SSHC Section 702.04.

B. Joint Filler and Sealers: In accordance with SCDOT SSHC Section 501.07.

C. Construction Joint Devices: Integral galvanized steel; 6 inch thick, formed to tongue and groove profile, with removable top strip exposing sealant trough, knockout holes spaced at 6 inches, ribbed steel spikes with tongue to fit top screed edge.

2.05 CONCRETE MIX

A. Mix concrete in accordance with ACI 304. Deliver concrete in accordance with ASTM C94.

B. Select proportions for normal weight concrete in accordance with SCDOT SSHC Section 501 and ACI 301.

C. Provide concrete to the following mix design:

| Unit | Measurement |
|---|---|
| Compressive Strength (28 day) | 3,000 psi |
| Water/cement ratio (maximum) | 0.58 by weight |
| Aggregate Size (maximum) | 3/4 inch |
| Air Entrained | 2-4 percent |
| Slump - Plus or minus 1 inch | 1-4 inches |

D. Use accelerating admixtures in cold weather only when approved by Engineer. Use of admixtures will not relax cold weather placement requirements.

E. Use calcium chloride only when approved by Engineer.

F. Use set retarding admixtures during hot weather only when approved by Engineer.

G. Add air entraining agent to normal weight concrete mix for work exposed to exterior.

PART 3 -- EXECUTION

3.01 EXAMINATION

A. Verify site conditions.

B. Verify compacted aggregate base is acceptable and ready to support paving and imposed loads.

C. Verify gradients and elevations of base are correct.

D. Verify requirements for concrete cover over reinforcement.

3.02 SUBBASE

A. Section 02200, Earthwork, forms the base construction for concrete driveway pavement replacement work.

B. Saw cut existing pavement prior to excavation of trench.

3.03 AGGREGATE PLACEMENT

A. Placement and construction requirements shall be in accordance with the SCDOT SSHC, Section 306 and as specified herein.

B. Spread aggregate over prepared substrate to a total compacted thickness of 4 inches.

C. Place aggregate and compact to specified density.

D. Level and contour surfaces to elevations and gradients indicated.

E. Add small quantities of fine aggregate to coarse aggregate as appropriate to assist compaction.

F. Add water to assist compaction. If excess water is apparent, remove aggregate and aerate to reduce moisture content.

G. Use mechanical tamping equipment in areas inaccessible to compaction equipment.

3.04 PREPARATION

A. Moisten base to minimize absorption of water from fresh concrete.

B. Coat surfaces of manhole, catch basin, and drop inlet frames with oil to prevent bond with concrete pavement.

C. Notify Engineer minimum 24 hours prior to commencement of concreting operations.

3.05 FORMING

A. Place and secure forms to correct location, dimension, profile, and gradient.

B. Assemble formwork to permit easy stripping and dismantling without damaging concrete.

C. Place joint filler vertical in position, in straight lines. Secure to formwork during concrete placement.

D. Exposed outside corners shall be chamfered.

E. Form ties shall be broken back a minimum of 3/4 inch from the surface of the concrete. No tie wire shall pass through the concrete.

3.06 REINFORCEMENT

A. Place welded steel wire fabric reinforcement at mid-height of slab.

B. Interrupt reinforcement at control joints.

C. Place reinforcement to achieve pavement and curb alignment as detailed.

D. Provide dowels at 12 inch on center at transverse joints and interruptions of concrete with one end of dowel set in capped sleeve to allow longitudinal movement.

E. Ensure that reinforcing is free from dirt, oil and excessive rust.

F. Support reinforcing bars in slabs on the ground on masonry blocks at least three inches from the ground. Minimum concrete cover for reinforcement shall be as required in ACI 318.

G. Support welded wire fabric so that it will be located in the center of the slab. Provide 6 inches minimum end and side laps.

H. Bar splices: 30 diameters, minimum.

3.07 PLACING CONCRETE

A. Before placing concrete, remove all debris and water from the place to be occupied by the concrete. Oil or wet forms. Securely place and fasten all inserts, hangers, etc.

B. Convey concrete in such a way as to prevent segregation. Limit free fall of concrete to five feet.

C. Deposit concrete as nearly as practical to its final position.

D. Thoroughly consolidate concrete by vibrating and spading. Do not use vibrators to cause concrete to flow along the forms.

E. Place concrete in accordance with ACI 301 and as specified in Section 03300.

F. Ensure reinforcement, inserts, embedded parts, formed joints, and accessories are not disturbed during concrete placement.

G. Place concrete continuously over the full width of the panel and between predetermined construction joints. Do not break or interrupt successive pours such that cold joints occur.

3.08 PATCHING

A. Patch gravel pockets, bad joints, voids, holes where ties are broken back and other defects which are not so unsatisfactory as to require removal of the section.

B. Remove all loose material. Wet surface six inches beyond the edge of the patch. Brush surface with a grout consisting of equal parts of Portland cement and fine sand.

C. Mix patch of the same materials as used in the concrete, except that no coarse aggregate is added.

D. Patch shall be applied immediately after the brush coat of grout. The patching mortar shall be prepared and allowed to stand approximately one hour before it is applied. No additional water shall be added.

3.09 JOINTS

A. Place expansion and contraction (control) joints as indicated on the Drawings. Align curb, gutter, and sidewalk joints.

B. Place joint filler between paving components and building or other appurtenances. Recess top of filler 1-1/4 inch for sealant placement.

C. Saw cut contraction joints 1/4 inch wide at an optimum time after finishing. Cut 1/2 into depth of slab.

3.10 CURING

A. Beginning immediately after placement, protect concrete from premature drying and from excessively hot or cold temperatures. Take steps to minimize moisture loss and maintain a relatively constant temperature for the period necessary for hydration of the cement and hardening of the concrete. During the curing period, protect concrete from damaging mechanical disturbances.

B. For concrete surfaces not in contact with forms, apply one of the following procedures immediately after completion of placement and finishing.
   1. Covering entire surface with burlap or similar moisture retaining fabric. Keep the covering continuously moist and in direct contact with the surface so that a film of water remains on the concrete surface throughout the curing period.
   2. Cover entire surface with nonstaining waterproof reinforced Type I paper conforming to ASTM C171 as soon as the concrete has hardened sufficiently to prevent surface damage. Lap side and ends a minimum of 3 inches. Seal all laps continuously with waterproof tape. Periodic additions of water are not required.

C. Continue curing in accordance with one of the above shall be continued for at least seven consecutive days. If one of the curing procedures is used initially, it may be replaced by one of the other procedures any time after the concrete is

one day old provided the concrete is not permitted to become surface dry during the transition.

3.11 FINISHING

A. Concrete Paving: Wood float.

B. Direction of Texturing: Transverse to pavement direction.

C. Ensure that exposed concrete is true to desired lines and contour, and free from stone pockets and honeycomb. After forms are removed, rub exposed surfaces with a wooden float and clear water or with carborundum brick, if necessary, until all form marks are removed leaving the surfaces smooth and of uniform appearance.

D. Cement wash is not allowed.

3.12 JOINT SEALING

A. Separate pavement from vertical surfaces with 1/2 inch thick joint filler.

B. Place joint filler in pavement pattern placement sequence. Set top to required elevations. Secure to resist movement by wet concrete.

C. Extend joint filler from bottom of pavement to bottom of sealer. Extend joint sealer to within 1/8 to 1/4 inch of finished surface. Conform to SCDOT SSHC Section 501.27 for finish joint sealer requirements.

3.13 REMOVAL OF FORMS

A. Sidewall forms may be removed as soon as the concrete has hardened sufficiently to permit removal without damage.

B. Leave forms for slabs, and other parts that support the weight of the concrete, in place until the concrete has attained sufficient strength to support all dead and live loads.

3.14 TOLERANCES

A. Maximum Variation of Surface Flatness: 1/4 inch in 10 ft.

B. Maximum Variation From True Position: 1/4 inch.

3.15 FIELD QUALITY CONTROL

A. Section 01400 – Quality Control.

B. Provide free access to Work and cooperate with appointed firm.

C. Submit proposed mix design of each class of concrete to inspection and testing firm for review prior to commencement of Work.

D. Tests of cement and aggregates may be performed to ensure conformance with specified requirements.

E. Four concrete test cylinders will be taken for every 50 or less cubic yards for each class of concrete placed.

F. One additional test cylinder will be taken during cold weather concreting, cured on job site under same conditions as concrete it represents.

G. One slump test will be taken for each set of test cylinders taken.

3.16 PROTECTION

A. Immediately after placement, protect pavement from premature drying, excessive hot or cold temperatures, and mechanical injury.

B. Do not permit vehicular or pedestrian traffic over pavement for 7 days minimum after finishing or until 75 percent design strength of concrete has been achieved.

3.17 SCHEDULES

A. Concrete Pavement: 3,000 psi 28 day concrete, 6 inches thick, 12x12 - W4xW4 WWF reinforcement.

- END OF SECTION -

SECTION 02604

UTILITY STRUCTURES

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Furnish all materials, labor, equipment, and tools required for the design, fabrication, delivery and installation of utility structures and appurtenances in accordance with the Drawings and as specified herein.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 02200 – Earthwork

B. Section 03200 – Reinforcing Steel

C. Section 03250 – Concrete Accessories

D. Section 03300 – Cast-in-Place Concrete

E. Section 03400 – Precast Concrete

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.

1. ASTM C478 – Specification for Precast Reinforced Concrete Manhole Sections

2. ASTM C857 – Minimum Structural Design Loading for Underground Precast Concrete Utility Structures

3. ASTM C990 - Specifications for Joints in Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants

1.04 SUBMITTALS

A. Submit samples and/or Shop Drawings in accordance with Section 01300, Submittals.

B. In addition to items listed in Section 03400, Precast Concrete, Shop Drawings shall include, but not be limited to:

1. Complete layout and installation Drawings and schedules with clearly marked dimensions.

2. Material certificates on all piping materials.

3. Structural design calculations sealed by a P.E. registered in the State of South Carolina. Design calculations for precast manholes and vaults shall include confirmation structures adequately resist flotation when they are totally empty and subjected to groundwater full height of structure.

4. Results of leakage test

## PART 2 -- PRODUCTS

### 2.01 PRECAST MANHOLES, VAULTS, AND METER BOXES

A. Precast utility structures shall be furnished with waterstops, sleeves and openings as noted on the Drawings. Box out for wall pipes shall conform accurately to the sizes and elevations of the adjoining pipes. Manholes to be lined with Raven 405Epoxy coating at 120mils nominal thickness. Precast utility structures shall be watertight and conform to the requirements of ASTM C 478 and ASTM C857 with the following modifications there to:

1. Materials shall conform to Section 03400, Precast Concrete.

2. Manholes shall meet the following:

   a. Manhole section shall have an internal diameter of 4'-0", unless noted otherwise.

   b. Minimum manhole wall thicknesses shall be 5 inches for 4 foot and 5 foot diameter manholes, 6 inches for 6 foot diameter manholes and 7 inches for 7 foot diameter manholes.

   c. Manholes and utility structures shall include ballast concrete and/or other means necessary to insure manholes resist flotation when empty and subjected to groundwater full height of structure.

   d. Precast manholes and utility structures shall be as manufactured by NC Products/Oldcastle, Tindall Products, or equal.

3. The date and name of manufacturer shall be marked inside each precast section.

4. No more than two lift holes may be cast or drilled in each section.

5. Dimensions shall be as shown on the Drawings.

6. Covers and frames shall be as specified in Section 2.10.

7. Mechanical Details such as piping, electrical, and other details shall be as shown on the Drawings.

B. Joints between manhole and utility structures riser sections and at base slabs shall be groove type.

2.02 CONCRETE

A. Concrete shall conform to Section 03300, Cast-in-Place Concrete.

2.03 REINFORCING

A. Reinforcing shall conform to Section 03200, Reinforcing Steel.

2.04 PRECAST CONCRETE

A. Precast concrete shall conform to Section 03400, Precast Concrete.

2.05 CASTINGS

A. Castings shall conform to Section 05540, Castings. Casting shall be of the type and size indicated on the Drawings.

2.06 STEPS

A. Steps shall be constructed of Grade 60 steel reinforcing rod (min. 1/2-inch) and completely encapsulated with a wear resistant and chemical resistant rubber.

B. Each step shall have a minimum vertical load resistance of 800 pounds and a minimum pull-out resistance of 400 pounds.

C. The steps shall have 11-inch minimum tread width and shall be placed at 16-inches on center, as shown on the Drawings.

D. Steps shall be cast in place with the concrete.

E. Steps shall only be installed as shown on the Drawings or required in the Specifications.

2.07 JOINT SEALANT

A. Joint sealant shall be a preformed flexible sealant conforming to the requirements of ASTM C990, paragraph 6.2, Butyl Rubber Sealant. Joint sealant shall be Pro-Stik Butyl Sealant by Press-Seal, Butyl-Nek Join Sealant by Henry ,CS-102 Butyl Rubber Sealant for all Precast Structures by ConSeal, or equal.

2.08 FLEXIBLE RUBBER SLEEVE

A. The spring set type shall have a stainless steel interior power sleeve or expander and shall be the PSX assembly by Press-Seal Gasket Corporation, or the Kor-N-Seal assembly by National Pollution Control Systems.

B. The cast-in-place type shall conform to ASTM C923 and shall include stainless steel take up clamps.

C. Flexible seal assemblies shall permit at least an eight (8) degree deflection from the center line of the opening in any direction while maintaining a watertight connection.

2.09 RUBBER BLADDER

A. The rubber bladder seal shall conform to ASTM C923 suitable for pressure testing at 10 psi minimum, with a 3/8 inch minimum wall thickness.

B. The rubber bladder seal shall contain an environmentally safe, anti-bacterial compound which turns into a high viscosity gel when in contact with pressurized water.

C. The rubber bladder seal shall be NPC Contour Seal by Kor-N-Seal, or equal.

2.10 COVERS AND FRAMES

A. Conform to ASTM Specification A-48.

B. Frame and cover design: Pattern approved by the Engineer with the word(s) "Sewer" and "BCWS" cast in the cover. (BCWS Sewer Panel 2H).

C. See Appendix F29, BCWS Approved Parts List, for approved standard, traffic-rated, watertight, and hinged frames and covers.

D. Manhole steps: Plastic reinforced (M.A. Ind. PS1), extruded aluminum, or cast iron; spacing and orientation as indicated on drawing details.

2.11 GRATES

A. Grates shall comply with Section 05540, Castings.

2.12 CONCRETE BALLAST

A. Concrete ballast shall be Class B1 concrete in conformance with Section 03300, Cast-in-Place Concrete. Ballast shall be provided as necessary to insure manhole resists flotation when empty and subjected to full height groundwater conditions.

2.13 FLEXIBLE JOINT SEALER

A. Flexible joint sealer shall be a rubber ring waterstop as manufactured by Fernco Joint Sealer Co., or equal.

2.14 EPOXY BONDING AGENT

A. Epoxy bonding agent shall conform to Section 03250, Concrete Accessories.

PART 3 -- EXECUTION

3.01 DESIGN CRITERIA

A. Minimum structural design loading for underground precast concrete vaults shall be as indicated in ASTM C857, unless otherwise noted herein. Precast items subjected to vehicular traffic shall be designed for H-20 traffic loading. Other precast items shall be designed for a vertical live load of 300 psf.

B. Walls of precast items shall be designed for a vertical surcharge of 100 psf.

C. Precast manholes and vaults shall be designed to resist flotation when totally empty and subjected to groundwater full height of the manhole/vault.

3.02 FABRICATION AND CASTING

A. Fabrication and casting shall conform to Section 03400, Precast Concrete, and to Section 03300, Cast-in-Place Concrete.

B. All base sections designated to receive concrete ballast and all electrical manholes shall extend monolithically a minimum of 6 inches beyond the outside face of the wall for the entire periphery. All other utility structures shall have a standard base.

C. Utility structures built around existing pipe shall have a cast-in-place base slab.

3.03 HANDLING, TRANSPORTING, AND STORING

A. Handling, transporting and storing of precast items shall comply with Section 03400, Precast Concrete.

3.04 INSTALLATION

A. Installation shall conform with Section 03400, Precast Concrete and with the manufacturer's recommendations or to Section 03300, Cast-in-Place Concrete.

B. Frames and covers or grates shall be set so that tops are at elevations indicated on the Drawings or flush with finished grade where no elevation is indicated.

C. Joints between riser sections shall be sealed with joint sealant.

D. All openings in utility structures shall have flexible rubber sleeves sized to fit the connecting pipe and installed to provide watertight joints in accordance with the manufacturer's recommendations. The interior of the sleeve shall be filled with Class B concrete.

E. Openings that are too large for flexible rubber sleeves shall utilize rubber bladder seals which are expanded by water injected using a pressure pump.

F. All units shall be installed plumb and level.

G. All lift holes and joints shall be filled with non-shrink grout conforming to Section 03600, grout inside and out.

H. The manhole frames shall be set to their required elevations either with grade rings or with two or three courses of brick masonry laid around the top of the upper wall section. Such brick work shall be given a 1-inch mortar coat on the inside and out.

I. Concrete ballast shall be placed so that it bears directly on the utility structure base against the outer wall monolithically encircling the structure for the full height indicated on the Drawings. Additional ballast may be required where the depth or elevation of the structure varies from the Drawings.

J. Connection to Existing Pipe

1. Verify the diameter and invert elevation of existing pipe to be connected to new utility structures prior to beginning work on the structures.

2. Provide adequate protection to prevent damage to the existing pipe.

3. Provide adequate means for plugging and/or transferring the existing flow in the pipe to allow for the construction of inverts and grouting.

4. Cut off the existing pipe sufficiently for connection to the new structure and remove.

5. Thoroughly clean all foreign matter and coat the pipe surface with epoxy adhesive where the pipe joins the new structure.

6. Install a flexible joint sealer around the pipe.

7. Grout inside and outside of wall penetration with nonshrink grout.

K. Backfill structures in accordance with Section 02200, Earthwork.

L. Clean all structures of any accumulation of silt, debris, or foreign matter and keep clean until final acceptance of the work.

M. Excavation shall conform to Section 02200, Earthwork.

N. Structure bases shall bear on a minimum of 8 inches of compacted stone unless otherwise indicated on the Drawings.

O. Channel Inverts

1. Inverts shall be placed using Class B1 concrete with forms sufficient to provide a smooth half-round shape as shown on the Drawings. Manhole bases employing full depth precast inverts are acceptable.

2. Where the slope of the line does not change through a manhole, a constant slope shall be maintained in the invert. Where slope changes occur within a given manhole, the transition shall be smooth and shall occur at the approximate center of the manhole.

3. Inverts shown on the Drawings are taken at the center of the manhole unless otherwise noted.

3.05 ADJUSTMENTS TO EXISTING UTILITY STRUCTURES

A. Adjust structures as indicated on the Drawings using concrete or cast iron adjustment rings by approved methods.

B. Clean covers and inlet castings of all foreign material and paint with one coat of coal tar epoxy.

3.06 ADJUSTING COLLARS AND FINAL ADJUSTMENTS

A. Adjusting collars shall be as shown on the Drawings. Final adjustments shall be made so that the manhole ring and cover will be smooth and flush with the finished grade of the adjacent surface, or as otherwise indicated on the Drawings for manholes shown above grade.

- END OF SECTION -

SECTION 02730

SANITARY GRAVITY SEWER LINES

## PART 1 -- GENERAL

### 1.01 SECTION INCLUDES

A. Sanitary sewer lines, manholes, fittings, accessories, and bedding

B. Municipal sewer service connections and clean-out access

C. Bore and jack casing

D. Creek crossing

### 1.02 RELATED SECTIONS

A. Section 02100 – Clearing, Grubbing, and Site Preparation

B. Section 02200 – Earthwork

C. Section 02276 – Erosion and Sedimentation Control

D. Section 02500 – Surface Restoration

E. Section 02910 – Final Grading and Landscaping

F. Section 02731 – Sanitary Gravity Sewer Lines Testing

G. Section 02733 – Sanitary Sewer Force Mains

H. Section 09801—MIC Coating System

### 1.03 DEFINITIONS

A. Bedding: Fill placed under, beside and directly over pipe, prior to subsequent backfill operations.

B. Foundation Stone: Aggregate material placed under bedding material due to over excavation, or removal of unsuitable material.

### 1.04 REGULATORY REQUIREMENTS

A. Conform to SCDHEC *Standards for Wastewater Facility Construction*: R.61-67.

PART 2 -- PRODUCTS

2.01 GENERAL

A. Unless otherwise specified, all methods of work and materials used in the work under this contract will conform to the current specifications of the American Society for Testing Materials (ASTM), the American Water Works Association (AWWA), the American National Standard Institute (ANSI), Commercial Standards (CS), or other design standards as approved by SCDHEC.

2.02 PIPE MATERIALS

A. Ductile Iron Gravity Sewer Pipe:

1. Pipe: ASTM A-746, latest revision, AWWA C150 (ANSI A 21.50), thickness class 52 for all sizes.

2. Joints: AWWA C111 (ANSI A21.11), push-on joints, push-on restrained joints, and mechanical joints as required, except as otherwise specified or indicated on the Drawings, such as carrier pipe threaded through steel casing under highways and railroads.

3. Fittings: Conform to AWWA C110 (ANSI A21.10).

4. Lining: Protecto 401™ by Vulcan Painters for all ductile iron pipe, joints, and fittings in accordance with specifications provided by Protecto 401 Ceramic Epoxy Company.

5. Coat exterior of the pipe and fittings with an asphaltic material approximately one (1) mil thick.

B. PVC Gravity Sewer Pipe:

1. Pipe: ASTM D3034, D1784 and D2241, latest revision, (SDR-26), cell classification 12454-B or C, with factory fabricated integral bell, 8 inch through 15 inch sizes. DR-18 C900 PVC for deep sewer installation (greater than 15 feet), and DR-18 C905 PVC for pipes 14” and larger. PVC pipes shall be green in color.

2. Joints: AWWA C111 (ANSI A21.11), push-on type rubber gasket joint devices.

3. Fittings: ASTM D3033 and D3034. Same materials as pipe, unless shown otherwise. Must be molded. Welded fittings are not approved.

C. Plastic Service Pipe: ASTM D3034, SDR-26, , Poly Vinyl Chloride (PVC) material; 4 inch and 6 inch sizes, push-on joint.

D. Steel Casing Pipe:

1. Pipe: ASTM A139, grade B with minimum yield strength of 35,000 psi; Exterior of the pipe shall be coated with coal tar epoxy coating.

2. Material and installation method: Conform to applicable highway encroachment permits and SCDOT Utility Accommodations Policy.

3. Size: The diameter of the casing shall be at least 12” larger than the maximum carrier pipe diameter (including all fittings).

4. Spacers: A minimum of two spacers per joint of pipe shall be used.

5. Minimum wall thickness:

| D.I. Carrier Pipe (Push-on Restrained Joint) Nominal Diameter (Inches) | Coated Casing Pipe (Welded Steel) Nominal Diameter (Inches) | Coated Casing Pipe (Welded Steel) Nominal Thickness (Inches) |
|---|---|---|
| 6 | 24 | 0.407 |
| 8 | 24 | 0.407 |
| 10 | 30 | 0.469 |
| 12 | 30 | 0.469 |
| 14 | 30 | 0.469 |
| 16 | 36 | 0.532 |
| 18 | 36 | 0.532 |
| 24 | 42 | 0.563 |
| 30 | 48 | 0.688 |

2.03 PRECAST MANHOLES

A. General:

1. Construct all sanitary sewer structures of precast reinforced concrete manhole sections conforming to standard specification ASTM C478 with circular confined rubber "O-ring" gasket joints or mastic seal, and flexible pipe connectors, both conforming to ASTM C443, C990 and C923.

2. Clear inside diameters:

| Pipe Size | Manhole Diameter |
|---|---|
| 8" - 12" | 4' |
| 14" - 18" | 5' |
| 21" - 30" | 6' |
| 36" or Larger | 7' |

Additionally, 5 feed minimum for manholes over 12’ deep and 5 feet minimum for inside drop manholes. Manholes between 8’ and 12’ deep may require 5 feed minimum diameter manholes if determined by BCWS.

3. Use larger manhole diameter if number of pipes entering and exiting or if the inlet and outlet angles reduce concrete between openings to less than 12 inches.

4. Wall thickness: 1/12th the inside diameter, but not less than four (4) inches.

5. Monolithic base thickness: 6 inches or greater for 4 foot diameter manholes; 8 inches or greater for 5 foot and 6 foot diameter manholes.

6. Eccentric cones: Use for all manholes 5 feet deep and greater; cone height not less than 32 inches nor greater than 48 inches.

7. Concentric cones: Avoid use if possible; use for manholes less than 5 feet deep or when drop inlets create a conflict with manhole joint locations; cone height not less that 16 inches nor greater than 20 inches.

8. Alternate for concentric cones or when less vertical height is necessary: flat top slabs with 24 inch diameter eccentric circular opening; thickness to be same as monolithic base but not less than 8 inches.

9. Minimum outside diameter at top of cone: Not less than 37.5 inches; allow for adjustment to finished grade with standard size concrete rings; limit adjustment to 2 rings maximum (not to exceed 8 inches).

10. Minimum access diameter: 24 inches.

B. Materials:

1. Aggregate: Sound, crushed, angular stone only; reference ASTM C-33, except that requirement for gradation does not apply; smooth or rounded stone (river rock) is not acceptable.

2. Cement: Type II, with a maximum tricalcium aluminate content of 8%. Submit certification and mill reports to the Engineer to assure cement quality.

3. Fly Ash: ASTM Designation C618 for Class C Fly Ash; may be added to concrete mix, but not as replacement for more than 10% of the cement; strengths as required by ASTM C478.

4. Compression tests: Furnish test results to the Engineer on one section for every production day in which fifteen or more sections are poured.

5. Absorption test: Furnish test reports to the Engineer showing that absorption does not exceed 6%.

C. Flexible Pipe Connections:

1. Join inlet and outlet pipes to the manhole with a synthetic rubber boot; boot must create a watertight seal with both manhole and pipe while allowing differential settlement.

2. Minimum material thickness: 0.375 inch.

3. Allowable deflection: Shall be within the manufacturer's recommendations.

4. Conform to ASTM C923.

5. Metallic accessories: Series 300 stainless steel.

D. Coatings:

As specified in Section 09801.

2.04 PIPE ACCESSORIES

A. Pipe Joint Couplings: Mechanical clamp ring type, stainless steel expanding and contracting sleeve, neoprene-ribbed gasket for positive seal.

B. Fittings: Same material as pipe molded or formed to suit pipe size and end design, in required tees, bends, elbows, clean-outs, reducers, traps and other configurations.

C. Locator Tape for Gravity Sewer: Magnetic detectable conductor, clear brightly colored plastic covering; imprinting to read CAUTION - BURIED SEWER LINE BELOW, or other similar wording approved by the Engineer, in large capital letters.

D. Transition between DI and PVC: MJ sleeves with Protecto 401 lining on existing gravity main applications. Fernco or similar couplings are not allowed. Molded PVC or DI transition fittings may be used on the installation of new gravity mains. See Appendix F29 for approved fittings.

2.05 EMBEDMENT MATERIALS

A. General: Embedment and foundation materials listed herein include a number of processed materials, plus the soil classifications listed under the Unified Soil Classification System (USCS; Method D 2487 and Practice D 2488). These

materials are grouped into five broad categories according to their suitability for this application.

B. Aggregate Bedding and Foundation Stone: ASTM C33. Class I - Angular, 6 to 40-mm (1/4 to 1 1/2-in.) graded stone, including a number of fill materials that have regional significance such as coral, No. 57 granite, air cooled blast furnace slag, cinders, crushed stone, and crushed shells. Bedding shall be inert in that it shall not deteriorate over time due to chemical contact or electrolysis.

C. Haunching Stone:

1. Class I - Angular, 6 to 40-mm (1/4 to 1 1/2-in.) graded stone.

2. Class II - Coarse sands and gravels with maximum particle size of 40 mm (1 1/2 in.), including variously graded sands and gravels containing a small percentage of fines, generally granular and non-cohesive, either wet or dry. Soil types GW, GP, SW, and SP are included in this class.

D. Initial Backfill to Top of Pipe:

1. Class I - Angular, 6 to 40-mm (1/4 to 1 1/2-in.) graded stone.

2. Class II - Coarse sands and gravels with maximum particle size of 40 mm (1 1/2 in.), including variously graded sands and gravels containing a small percentage of fines, generally granular and non-cohesive, either wet or dry. Soil types GW, GP, SW, and SP are included in this class.

E. Initial Backfill Over Pipe:

1. Class II - Coarse sands and gravels with maximum particle size of 40 mm (1 1/2 in.), including variously graded sands and gravels containing a small percentage of fines, generally granular and non-cohesive, either wet or dry. Soil types GW, GP, SW, and SP are included in this class.

2. Class III - Fine sand and clayey gravels, including fine sands, sand-clay mixtures, and gravel-clay mixtures. Soil types GM and SM are included in this class.

F. Unsuitable Materials: These materials are not recommended for bedding, haunching, or initial backfill:

1. Class IV - Silt, silty clays, and clays, including inorganic clays and silts of medium to high plasticity and liquid limits. Soil Types MH, ML, CH and CL are included in this class.

2. Class V - This class includes the organic soils OL, OH, and PT as well as soils containing frozen earth, debris, rocks larger than 40 mm (1 1/2 in.) in diameter, and other foreign materials.

PART 3 -- EXECUTION

3.01 PREPARATION

A. Excavate pipe trench in accordance with ASTM D2321 for work of this section. Hand trim excavation for accurate placement of pipe to elevations indicated.

B. Remove large stones or other hard matter that could damage pipe or impede consistent backfilling or compaction.

C. Trench width not to exceed that necessary for joining the pipe and placing and compacting the haunching and initial backfill. Compaction of the haunching and initial backfill to extent of trench wall.

D. Stabilize poor or running soil conditions. Select and utilize a suitable method of trench wall and trench bottom stabilization. Methods to be approved by the Engineer.

E. Utilize well points or under drain systems to control excessive ground or running water.

F. Correct over excavation with foundation stone.

3.02 EXAMINATION

A. Verify that trench cut and excavation base is ready to receive work and excavations, dimensions, and elevations are as indicated on the Drawings.

3.03 BEDDING

A. Hand trim excavations to required elevations.

B. Place bedding material at trench bottom, level materials in continuous layers not exceeding 8 inches compacted depth (95 percent compaction).

C. Maintain moisture content of bedding material at optimum or above to attain required compaction density.

3.04 INSTALLATION – PIPE

A. Install pipe, fittings, and accessories in accordance with ASTM D2321, ASTM A746 and manufacturer's instructions.

B. Lay pipe in an upstream direction to the appropriate line and slope gradients noted on profile drawings, with maximum variation from true slope of 0.02%. Final slope must meet or exceed SCDHEC minimum slope requirements. Position bell end of pipe in upgrade direction.

C. Refer to ASTM D2321 for additional trenching and backfill requirements. Do not displace or damage pipe when compacting.

D. Warning Tape for Gravity Sewer: Place continuous 6" wide brightly colored warning tape, imprinted to read in large capital letters "CAUTION - BURIED SEWER LINE BELOW", or other similar wording approved by BCWS, over all new piping, 24" below finish grade.

E. Connect service tee-wyes, piping, and cleanouts as shown on the plan sheets.

F. Water shall not be allowed to run through the pipe or stand in the trench.

G. Thickness class 52 DIP or PVC in steel or HDPE casing shall be used when:
1. Crossing beneath storm drainage pipe with less than two feet of clearance;
2. Crossing above or under water main within 18 inches.

H. Selection of pipe materials shall comply with the following:
1. Less than three feet (< 3') of cover: class 52 DIP;
2. Greater than 3 feet but less than 15 feet (>3' but <15') in depth: SDR-26 PVC and in accordance with the crossing requirements listed above.
3. Greater than 15 feet but less than 24 feet (>15' but <24') in depth: class 52 DIP or DR-18 C900 PVC;
4. Greater than 24 feet (>24') in depth: class 52 DIP.

I. Sewer Line Relationship to Water Mains: In accordance with SCDHEC Regulation 61-67.

1. There shall be no physical connections between a public or private potable water supply system and a sewer, or appurtenance thereto which may permit the passage of any sewage or polluted water into the potable supply. No potable water pipe shall pass through or come into contact with any part of a sewer manhole.

2. Sewers shall be laid at least 10 feet horizontally from any existing or proposed potable water main. The distance shall be measured edge to edge. In cases where it is not practical to maintain a 10 foot separation, SCDHEC may allow deviation on a case-by-case basis, if supported by data from the Design Engineer.

3. Sewers crossing potable water mains shall be laid to provide a minimum vertical separation of 18 inches between the outside of the potable water main and the outside of the sewer. This shall be the case whether the

potable water main is above or below the sewer, but preferably above the sewer. Where a new sewer line crosses a new potable water main, a full length of pipe shall be used for both the sewer line and potable water main and the crossing shall be arranged so that the joints of each line shall be as far as possible from the point of crossing and each other. Where a potable water main crosses under a sewer, adequate structural support shall be provided for the sewer line to prevent damage to the potable water main while maintaining line and grade.

4. When it is impossible to obtain the distances specified above, SCDHEC may allow an alternative design. Consult SCDHEC's "Standards for Wastewater Facility Construction" for guidelines.

3.05 INSTALLATION - MANHOLES

A. Place precast manhole sections in accordance with ASTM C891 and manufacturer's recommended practice. Ensure that manhole steps are properly spaced and aligned. Begin construction of each manhole as soon as pipe laying is complete.

B. Build up manhole inverts to properly take care of the flow through manholes and to lessen the drop from one sewer to another. Stop all water flowing through manholes before building inverts.

C. Drop manholes are required where the invert differential is 18 inches or more.

D. Set manhole tops at elevations shown on the drawings or as determined by the Engineer for each individual manhole. Leveling and final grading of manhole frames and covers shall be accomplished by using concrete rings. Concrete rings shall not exceed maximum of two 4" concrete grade rings or one 6" grade ring. The total number of grade rings shall not exceed 8" in thickness.

E. Manhole top elevations shall be greater than or equal to the fifty (50) year flood elevation, unless watertight covers are provided. Watertight covers shall be provided if manhole is installed in an area that may be affected by street runoff (i.e. pavement, driveway, sidewalk, etc.), a natural drainage area or ditch that is subject to flooding.

F. Where sewer main is installed in an overgrown area that will not be developed in the future (i.e. wetlands, heavily wooded area, buffer zones, etc.), manhole top elevation may be allowed to be installed 2' above the finish grade. Hinged or swivel manhole frame and cover shall be used. Water-tight hinged manhole frame and cover shall be used if the manhole top elevation is below the fifty (50) year flood elevation. Hinged manhole frames shall be red head anchored at two points.

G. Set cast iron frames in mortar with even bearing.

H. Ensure that manhole construction keeps pace with sewer line construction. If, in the Engineer's judgment, manhole construction is not keeping pace with the

pipe laying, pipe laying may be stopped until the manhole construction catches up.

I. Plug new connections to existing manholes and/or existing pump stations to minimize the inflow of water or materials into the existing collection system. Leave newly constructed manholes clean and in good working order. Maintain such conditions throughout the construction period. Unplug the new connections in the presence of a BCWS representative after the Permit to Operate for the new system has been obtained. BCWS open fixture ordinances will be enforced when a violation is discovered.

J. Where a drop installation is required when tying into an existing manhole, use inside drop for 6" inlet and outside drop for 8" and larger inlet. If the existing manhole is not a precast concrete manhole or is in poor condition as determined by BCWS, the existing manhole shall be replaced. Drop installation is prohibited on existing manholes less than 8' deep.

K. Where a drop installation is required when constructing a new manhole, use inside drop and 5' minimum diameter manhole. Outside drop installation is prohibited. If more than one inside drop inlet is installed in one manhole, the manhole shall be 6' or larger in diameter. Drop installation is prohibited on manholes less than 8' deep.

L. Contact BCWS for an inspection on a dog house manhole immediately after it is installed.

3.06 INSTALLATION - BORE AND JACK CASING

Where required by SCDOT permit, install steel casing pipe under highway using the bore and jack, or similar tunneling method that has been reviewed and approved by the Engineer. Thread and support ductile iron sewer pipe through casing at location and grades as indicated on the drawings.

3.07 INSTALLATION - WATER CROSSING

Install ductile iron sewer pipe below water level using subaqueous trenching and pipe laying techniques that have been reviewed and approved by the Engineer. Ensure that pipe is installed at location and grades indicated on the drawings.

3.08 INSTALLATION - SERVICE CONNECTIONS

A. Location: Layout and install service connections as directed by the Engineer.

B. Description of Service Connection Components: 8 inch by 6 inch service tee-wye; 6 inch fittings as required to achieve minimum slope and proper direction of flow; sufficient length of 6 inch service pipe to reach the property line of lot(s) to be served; end fitting(s) (6 inch by 4 inch wye or a 6 inch by 4 inch double-

wye with plug(s) for residential services, and 6 inch by 6 inch wye or double-wye for commercial projects); five feet of metallic locator tape; and a two foot long marker stake (treated 2 inch by 4 inch lumber, two feet above grade).

C. Install in accordance with ASTM D2321 and connection details shown on the Drawings.

D. Required Record Measurements: Provide the Engineer with two measurements for each service: (1) distance from the center of the nearest downstream manhole to the centerline of the service lateral, and (2) distance from the centerline of the gravity sewer line to the termination point of the service pipe and end fitting.

E. New service connections to be made on existing mains requires the sole use of a DI tee or wye. All fittings are to be lined with Protecto 401 ceramic epoxy lining. When depth allows, molded PVC repair couplings may be used for the sleeved joint connections with the existing main. When depth does not allow, DI MJ solid sleeves must be used for the sleeved joint connections. See F29 BCWS Approved Part List for approved fittings.

F. For commercial developments, a sewer service shall be installed for each unit inside each building with the exception of apartment buildings that are multi-stories. Multi-stories apartment complexes shall have a master service for each building. Where water services are provided by another municipality, sewer shall be served the same way the water will be metered.

G. A 4” elder valve shall be installed on any residential sewer service that is installed in a project that BCWS will not own and operate the water system.

H. Mark curb with the letter “X” for locations of sewer services. Markings shall be stamped and no more than ½” deep, located on top of the curb. Markings shall not be located too close to an existing joint in the curb and shall not extend across the whole curb/gutter section.

I. Mark curb with the letter “MH” for locations of manholes. Markings shall be stamped and no more than ½” deep, located on top of the curb. Markings shall not be located too close to an existing joint in the curb and shall not extend across the whole curb/gutter section.

## 3.09 PAVEMENT REPAIR AND REPLACEMENT

A. Replace or repair all surface courses on roads and routes, sidewalks and driveways that are removed or damaged in the construction of this project. Repair or replace pavements in accordance with the current S. C. Department of Transportation's Standard Specifications for Highway Construction.

B. Repair cuts transverse to surfaced roadways and driveways using a minimum of an eight inch thick stabilized aggregate base course topped with (1) 200 lbs./sq. yd. of hot plant mix asphaltic concrete or (2) six inch thick cast-in-place

concrete, as appropriate to match pre-existing condition and as required by the Engineer and permitting agency.

C. Maintain all replaced or repaired bituminous paving and concrete paving, for a period of two (2) year following acceptance of the project.

D. Maintain traffic on all roads and routes which must be crossed by sewer lines. If the open cut method is used, either (1) make two separate cuts to allow one lane open to traffic at all times, or (2) provide suitable detour.

E. Place excavated material on the traffic side of the trench forming a barrier between vehicular traffic and the construction trench. Otherwise, utilize moveable barricades, which can be relocated as the work progresses.

F. Provide construction signs, guards, flashing warning lights and flagmen in accordance with the current S.C. Department of Transportation's regulations and guidelines.

3.10 PROTECTION OF FINISHED WORK

Protect pipe and aggregate cover from damage or displacement until backfilling operation is in progress.

3.11 WORK WITHIN PUBLIC RIGHT OF WAY

Work in public rights of way shall be in accordance with the encroachment permit issued by the controlling entity. All work in the rights of way shall be complete within 500 feet of the forward progress unless the encroachment permit dictates more stringent requirements. The Engineer will suspend work if the 500 feet requirement is not met. In determining this level of completion the Engineer will evaluate the final grading and erosion and sedimentation compliance.

- END OF SECTION -

SECTION 02731

SANITARY GRAVITY SEWER LINE TESTING

PART 1 -- GENERAL

1.01 SECTION INCLUDES

A. Low Pressure Air Test

B. Deflection Test

1.02 REGULATORY REQUIREMENTS

A. Conform to SCDHEC Standards for Wastewater Facility Construction: R.61-67.

PART 2 – EXECUTION

2.01 GENERAL

A. Compaction testing, if required by the Engineer, will be performed in accordance with ASTM D1557.

B. Moisture content testing, if required by the Engineer, will be performed in accordance with ASTM D1557.

C. If tests indicate work does not meet specified requirements, remove work, replace and retest at no cost to the Owner.

D. Outward (exfiltration) or inward (infiltration) leakage of gravity sewers shall not exceed two hundred (200) gallons per inch of pipe diameter per mile per day.

E. Locate and repair defective joints, pipes or manholes, and retest until the allowable test rates are within the allowances specified below.

F. Testing sequences shall be as follows:

1. Deflection test

2. Low-pressure air test

3. CCTV inspection

2.02 LOW PRESSURE AIR TEST

A. Perform low pressure air test in accordance with ASTM F1417 and UNI B-6-90.
B. Equipment

1. Low pressure air testing is to be conducted by the Contractor using an air source and other specified equipment provided by the same, which is properly calibrated and oil free. The air source shall utilize a single control panel consisting of a main shut-off valve, pressure-regulating valve, 9 psig pressure relief valve, input pressure gage, and continuous monitoring pressure gage having a range of pressure from 0 to at least 10 psi with minimum divisions of .1 psi. The pressure gage used for continuous monitoring should be at least 4" in diameter and have an accuracy of + .04 psi.

2. Separate air hoses shall be provided for: the introduction of the low pressure air from the control panel to the sealed line, the constant monitoring of air pressure build-up in the line, and the inflation of pneumatic plugs from the control panel.

3. Either mechanical or pneumatic plugs may be used to isolate sections of sewer main to be tested so long as they have the capability to resist the pressures inside the sewer line associated with this test. As well as isolating the sewer main itself by plugging manhole inverts, all service laterals, stub outs, and other fittings of this type should be properly sealed so as not to cause a failure of this test.

C. Procedure

Note: Conduct deflection test prior to low-pressure air test.Lines must be cleaned by flushing or by other means before the low-pressure air test is to begin.

1. Isolate the sewer line to be tested with the plugs referenced above and ensure that all other outlets from which air could escape are properly sealed. In this step of the procedure, it is necessary to inspect the manhole invert being plugged to be sure that it has no damage which will be covered by the plug and not detected with the low-pressure air test.

2. Determine the duration of the test by using the formula found below or by consulting the accompanying tables at the end of this section.

$$T = 0.085\ DK/Q$$

Where:

T = Shortest time in seconds allowed for the air pressure to drop 1.0 psig (or .5 psig in circumstances where a shorter test duration is desired)
K = 0.000419 DL, but not less than 1.0
Q = 0.0015 cubic feet/minute/square foot internal pipe surface area
D = Nominal pipe diameter in inches
L = Length of pipe being tested in feet

3. Begin the test by connecting the air source to the inlet tap. Slowly add air until the internal pressure of the test section reaches a pressure 4.0 psig greater than the average back pressure of any groundwater above the pipe as long as the internal pressure does not exceed 9.0 psig. If ground water back pressure exists, it must be quantified by the Engineer prior to testing.

4. After the constant pressure of 4.0 psig (greater than the average ground water back pressure) is attained, the air supply should be controlled to keep the pressure at 4.0 psig (greater than the average ground water back pressure) for at least two minutes allowing the entering air's temperature to reach equilibrium with the temperature of the pipe wall.

5. Once the pressure has stabilized to 4.0 psig (greater than the average ground water back pressure) disconnect the air supply from the control panel. Observe the continuous monitoring gage and decrease the internal pressure to no less than 3.5 psig (greater than the average ground water back pressure). At a reading of 3.5 psig or within the range of 3.5 to 4.0 psig, stop decreasing the pressure and commence timing with a stopwatch or any other timing device capable of being 99.8 percent accurate.

**6.** Once the predetermined time period from the formula or table above has elapsed, observe the continuous monitoring gage to obtain the amount of pressure lost during the test duration. If the pressure drop is found to be less than 1.0 psig (or 0.5 psig in circumstances where a shorter test duration is desired), the section is presumed to be free of any leaks or defective joints. If the pressure drop is 1.0 psig or greater (0.5 psig or greater in circumstances where a shorter test duration is desired), the test section has failed due to excessive pressure loss. When low-pressure air testing of a sewer line results in a failure the Contractor, at his/her own expense, shall detect the leak or defect and repair or replace whatever is necessary to remedy such defect in a manner acceptable to the Owner.

2.03 DEFLECTION TEST

A. Perform deflection test on all flexible pipe.

B. Deflection shall not exceed 5%.

C. Perform initial deflection testing after the final backfill and compaction has been in place at least thirty (30) calendar days and prior to placing the sewer lines into operation. Perform final deflection testing during the 12th month of operation and prior to expiration of the Contractor's warranty and performance bond.

D. Perform deflection test using a rigid ball or mandrel having a diameter equal to 95% of the inside diameter of the pipe. Perform test without use of mechanical pulling devices.

| 5% Mandrel (In.) | | | |
|---|---|---|---|
| Nominal OD | C900, DR-18 | C905, DR-18 | D3034, SDR-26 |
| 6” | 5.64 | | 5.33 |
| 8” | 7.37 | | 7.11 |
| 10” | 9.01 | | 8.87 |
| 12” | 10.70 | | 10.55 |
| 14” | | 12.40 | |
| 16” | | 14.09 | |
| 18” | | 15.78 | |
| 20” | | 17.47 | |
| 24” | | 20.84 | |

TABLE 1: MINIMUM SPECIFIED TIME REQUIRED FOR A 1.0 PSIG PRESSURE DROP FOR SIZE AND LENGTH OF PIPE INDICATED FOR Q = 0.0015

| Pipe Diameter (in.) | Minimum Time (min:sec) | Length for Minimum Time (ft.) | Time for Longer Length (sec) | Specification Time (min:sec) for Length L Shown Below in feet | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 100 | 150 | 200 | 250 | 300 | 350 | 400 | 450 |
| 4 | 3:46 | 597 | 0.380 L | 3:46 | 3:46 | 3:46 | 3:46 | 3:46 | 3:46 | 3:46 | 3:46 |
| 6 | 5:40 | 398 | 0.854 L | 5:40 | 5:40 | 5:40 | 5:40 | 5:40 | 5:40 | 5:42 | 6:24 |
| 8 | 7:34 | 298 | 1.520 L | 7:34 | 7:34 | 7:34 | 7:34 | 7:36 | 8:52 | 10:08 | 11:24 |
| 10 | 9:26 | 239 | 2.374 L | 9:26 | 9:26 | 9:26 | 9:53 | 11:52 | 13:51 | 15:49 | 17:48 |
| 12 | 11:20 | 199 | 3.418 L | 11:20 | 11:20 | 11:24 | 14:15 | 17:05 | 19:56 | 22:47 | 25:38 |
| 15 | 14:10 | 159 | 5.342 L | 14:10 | 14:10 | 17:48 | 22:15 | 26:42 | 31:09 | 35:36 | 40:04 |
| 18 | 17:00 | 133 | 7.692 L | 17:00 | 19:13 | 25:38 | 32:03 | 38:27 | 44:52 | 51:16 | 57:41 |
| 21 | 19:50 | 114 | 10.470 L | 19:50 | 26:10 | 34:54 | 43:37 | 52:21 | 61:00 | 69:48 | 78:31 |
| 24 | 22:40 | 99 | 13.674 L | 22:47 | 34:11 | 45:34 | 56:58 | 68:22 | 79:46 | 91:10 | 102:33 |
| 27 | 25:30 | 88 | 17.306 L | 28:51 | 43:16 | 57:41 | 72:07 | 86:32 | 100:57 | 115:22 | 129:48 |
| 30 | 28:20 | 80 | 21.366 L | 35:37 | 53:25 | 71:13 | 89:02 | 106:50 | 124:38 | 142:26 | 160:15 |
| 33 | 31:10 | 72 | 25.852 L | 43:05 | 64:38 | 86:10 | 107:43 | 129:16 | 150:43 | 172:21 | 193:53 |
| 36 | 34:00 | 66 | 30.768 L | 51:17 | 76:55 | 102:34 | 128:12 | 153:50 | 179:29 | 205:07 | 230:46 |

(Table taken from UNI-B-6-90)

TABLE 2: MINIMUM SPECIFIED TIME REQUIRED FOR A 0.5 PSIG PRESSURE DROP FOR SIZE AND LENGTH OF PIPE INDICATED FOR Q = 0.0015

| Pipe Diameter (in.) | Minimum Time (min:sec) | Length for Minimum Time (ft.) | Time for Longer Length (sec) | Specification Time (min:sec) for Length L Shown Below in feet | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 100 | 150 | 200 | 250 | 300 | 350 | 400 | 450 |
| 4 | 1:53 | 597 | 0.190 L | 1:53 | 1:53 | 1:53 | 1:53 | 1:53 | 1:53 | 1:53 | 1:53 |
| 6 | 2:50 | 398 | 0.427 L | 2:50 | 2:50 | 2:50 | 2:50 | 2:50 | 2:50 | 2:51 | 3:12 |
| 8 | 3:47 | 298 | 0.760 L | 3:47 | 3:47 | 3:47 | 3:47 | 3:48 | 4:26 | 5:04 | 5:42 |
| 10 | 4:43 | 239 | 1.187 L | 4:43 | 4:43 | 4:43 | 4:57 | 5:56 | 6:55 | 7:54 | 8:54 |
| 12 | 5:40 | 199 | 1.709 L | 5:40 | 5:40 | 5:42 | 7:08 | 8:33 | 9:58 | 11:24 | 12:50 |
| 15 | 7:05 | 159 | 2.671 L | 7:05 | 7:05 | 8:54 | 11:08 | 13:21 | 15:35 | 17:48 | 20:02 |
| 18 | 8:30 | 133 | 3.846 L | 8:30 | 9:37 | 12:49 | 16:01 | 19:14 | 22:26 | 25:38 | 28:51 |
| 21 | 9:55 | 114 | 5.235 L | 9:55 | 13:05 | 17:27 | 21:49 | 26:11 | 30:32 | 34:54 | 39:16 |
| 24 | 11:20 | 99 | 6.837 L | 11:23 | 17:57 | 22:48 | 28:30 | 34:11 | 39:53 | 45:35 | 51:17 |
| 27 | 12:45 | 88 | 8.653 L | 14:25 | 21:38 | 28:51 | 36:04 | 43:16 | 50:30 | 57:42 | 46:54 |
| 30 | 14:10 | 80 | 10.683 L | 17:48 | 26:43 | 35:37 | 44:31 | 53:25 | 62:19 | 71:13 | 80:07 |
| 33 | 15:35 | 72 | 12.926 L | 21:33 | 32:19 | 43:46 | 53:52 | 64:38 | 75:24 | 86:10 | 96:57 |
| 36 | 17:00 | 66 | 15.384 L | 25:39 | 38:28 | 51:17 | 64:06 | 76:55 | 89:44 | 120:34 | 115:23 |

(Table taken from UNI-B-6-90)

- END OF SECTION -

SECTION 02733

SANITARY SEWER FORCE MAINS

PART 1 -- GENERAL

1.01 SECTION INCLUDES

A. Sanitary sewer force mains, fittings, accessories, and bedding

B. Construction procedures

1.02 RELATED SECTIONS

A. Section 02200 – Earthwork

B. Section 02276 – Erosion and Sedimentation Control

C. Section 02730 – Sanitary Gravity Sewer Lines

D. Section 02734 – Sanitary Sewer Force Main Testing

1.03 REGULATORY REQUIREMENTS

A. Conform to SCDHEC Standards for Wastewater Facility Construction: R.61-67.

PART 2 -- PRODUCTS

2.01 GENERAL

A. Ductile Iron Force Main:

1. Pipe: AWWA C150 (ANSI A 21.50), thickness class 52 for all sizes, except as otherwise set forth in the Drawings; and AWWA C151 (ANSI A 21.51), bell & spigot end and mechanical end.

2. Joints: Push-on joints, mechanical joints, and flanged joints as indicated in the drawings. Push-on and mechanical joints shall conform to AWWA C111 (ANSI A21.11). Provide gasket composition suitable for exposure to sanitary sewage. Flanged joints shall conform to AWWA C115 (ANSI A21.15). Component flanges shall be rated for a working pressure of 250 psi or greater.

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3. Fittings: Ductile iron, manufactured in accordance with AWWA C110 Class 350; or compact ductile iron, manufactured with AWWA C153 Class 350. Fittings to be designed to accommodate the type of pipe used.

4. Lining: Protecto 401™ by Vulcan Painters or TNEMEC Perma-Shield series 431 for all ductile iron pipe, joints, and fittings in accordance with specifications provided by Protecto 401 Ceramic Epoxy Company.

5. Coat exterior of pipe intended for below grade installation with an asphaltic material approximately one (1) mil thick.

6. Ductile iron pipe intended for above grade installation shall be painted as follows:

    a. Surface Preparation: Remove all dirt, dust, grease, oils, and all other foreign matter from the surface. Clean the surface in accordance with SSPC SP-6/NACE3 Commercial Blast Cleaning, latest revision. The surface shall be clean and dry prior to painting. Fill all unwelded seams or joints as needed per the manufacturer's recommendations.

    b. First Coat: Apply Tnemec Series 66HS Hi-Build Epoxoline/Series 161HS TnemeFascure or Sherwin Williams Macropoxy 646 at 4.0 - 6.0 dry mils. This coat shall not exceed 3.0 dry mils. Allow coat to dry overnight, minimum 12 hours, to cure.

    c. Second Coat: Apply Tnemec Series 66HS Hi-Build Epoxoline/Series 161HS TnemeFascure or Sherwin Williams Macropoxy 646 at 4.0 - 6.0 dry mils. This coat shall not exceed 3.0 dry mils. Allow coat to dry overnight, minimum 12 hours, to cure.

    d. Third Coat: Apply Tnemec Series 740-UVX GR33 or Sherwin Williams Hi Solids Polyurethane GR33 at 3.0 - 5.0 dry mils.

    Note: A NACE Level 3 certified technical representative from the paint manufacturer shall visit the job site to support the Contractor's personnel and/or the Owner as needed. A letter from the manufacturer shall be provided with the closeout submittal stating the project was completed in compliance with the manufacturer's recommendation and the project specifications.

B. PVC Force Main:

1. Pipe: ASTM D-2241, pipe 14" to 48" in diameter must conform to AWWA C905 with cast iron pipe equivalent outside diameters, class 165 (DR 25). Pipe 4" to 12" in diameter must conform to AWWA

C900, with cast iron pipe equivalent outside diameters, Class 150 (DR 18). Pipe smaller than 4" in diameter must conform to ASTM D1784, D2241, and F477. PVC force main shall be green. These statements prove true unless otherwise indicated on the drawings.

2. Joints: Join by means of a push on bell joint which is to be an integral part of the barrel in conformance with AWWA C900. Provide gasket composition suitable for exposure to sanitary sewage.

3. Fittings: For pipe less than 4" in diameter, PVC fittings to conform to the material requirements for PVC pipe described herein. For pipe diameters 4" to 8" in diameter, use PVC molded fittings with restraint joints. For pipe diameters 8" or greater, provide mechanical joint fittings conforming to 2.1.A.3. of this Section. Provide gasket composition suitable for exposure to sanitary sewage.

4. Pipe to bear the National Sanitation Foundation seal of approval. Comply with the requirements of Type I, Grade I of the ASTM resin specification D-1784. Certificates of conformance with the foregoing specifications to be furnished with each lot of pipe supplied.

5. Thermoplastic pipe shall not be used above grade.

C. Steel Casing Pipe:

Refer to Section 02730 Sanitary Gravity Sewer Lines.

2.02 RECEIVING MANHOLES

A. Coat manholes receiving discharge from force mains and the next manhole downstream with Raven 405 Epoxy Coating or Sherwin Williams Duraplate 6100 at 120 mils nominal thickness.

2.03 AIR RELEASE VALVES AND MANHOLES

A. Vent-Tech Model SXG- Series C. 145 psi (10 Bar)- Combination Air Valve for Wastewater. Sizes and locations shall be as indicated on the Drawings.

B. Air release valves shall be non-slam air release valves.

C. For underground installations, provide precast manhole with cover and frame as specified and a concrete valve marker post for each valve location.

D. Coat air release manholes and pipes inside air release manholes with Raven 405 Epoxy Coating or Sherwin Williams Duraplate 6100 at 120 mils nominal thickness.

2.04 PIPE ACCESSORIES

A. Pipe Joint Couplings: Mechanical clamp ring type, stainless steel expanding and contracting sleeve, neoprene-ribbed gasket for positive seal.

B. Fittings: Same material as pipe molded or formed to suit pipe size and end design, in required tees, bends, elbows, reducers and other configurations.

C. Locator Tape: Magnetic detectable conductor, clear brightly colored plastic covering; imprinting to read CAUTION - BURIED SEWER LINE BELOW, or other similar wording approved by the Engineer, in large capital letters.

D. Copper Tracer Wire: Place continuous 12-guage insulated solid copper tracer wire over all sanitary sewer force mains. Insulation color shall be green.

2.05 EMBEDMENT MATERIALS

A. General: Embedment and foundation materials listed herein include a number of processed materials, plus the soil classifications listed under the Unified Soil Classification System (USCS; Method D 2487 and Practice D 2488). These materials are grouped into five broad categories according to their suitability for this application.

B. Aggregate Bedding and Foundation Stone: ASTM C33. Class I - Angular, 6 to 40-mm (1/4 to 1 1/2-in.) graded stone, including a number of fill materials that have regional significance such as coral, No. 57 granite, air cooled blast furnace slag, cinders, crushed stone, and crushed shells. Bedding shall be inert in that it shall not deteriorate over time due to chemical contact or electrolysis.

C. Initial Backfill Over Pipe:
   1. Class II - Coarse sands and gravels with maximum particle size of 40 mm (1 1/2 in.), including variously graded sands and gravels containing a small percentage of fines, generally granular and non-cohesive, either wet or dry. Soil types GW, GP, SW, and SP are included in this class.

   2. Class III - Fine sand and clayey gravels, including fine sands, sand-clay mixtures, and gravel-clay mixtures. Soil types GM and SM are included in this class.

D. Unsuitable Materials: These materials are not recommended for bedding, haunching, or initial backfill:

   1. Class IV - Silt, silty clays, and clays, including inorganic clays and silts of medium to high plasticity and liquid limits. Soil Types MH, ML, CH and CL are included in this class.

2. Class V - This class includes the organic soils OL, OH, and PT as well as soils containing frozen earth, debris, rocks larger than 40 mm (1 1/2 in.) in diameter, and other foreign materials.

PART 3 -- EXECUTION

3.01 PREPARATION

A. Excavate pipe trench in accordance with ASTM D2321 for work of this section. Hand trim excavation for accurate placement of pipe to elevations indicated.

B. Remove large stones or other hard matter that could damage pipe or impede consistent backfilling or compaction.

C. Trench width not to exceed that necessary for joining the pipe and placing and compacting the initial backfill. Compaction of the initial backfill to extent of trench wall.

D. Stabilize poor or running soil conditions. Select and utilize a suitable method of trench wall and trench bottom stabilization. Methods to be approved by the Engineer.

E. Utilize well points or under drain systems to control excessive ground or running water.

F. Correct over excavation with foundation stone.

3.02 EXAMINATION

A. Verify that trench cut and excavation base is ready to receive work and excavations, dimensions, and elevations are as indicated on the Drawings.

3.03 BEDDING

A. Hand trim excavations to required elevations.

B. Place bedding material at trench bottom, level materials in continuous layers not exceeding 8 inches compacted depth (95 percent compaction of modified proctor).

C. Maintain moisture content of bedding material at optimum or above to attain required compaction density.

3.04 INSTALLATION - PIPE

A. Install pipe, fittings, and accessories in accordance with ASTM D2321 and manufacturer's instructions. DIP force main, fittings, and accessories to be installed in accordance with AWWA C-600. Seal joints watertight.

B. Lay pipe in an upstream direction to the appropriate line and slope gradients noted on profile drawings.

C. Refer to ASTM D2321 for additional trenching and backfill requirements. Do not displace or damage pipe when compacting.

D. All sewers shall be constructed with a minimum of three (3) feet of cover, unless justified by the Engineer and approved by SCDHEC.

E. Sewer Line Relationship to Water Mains: In accordance with SCDHEC Regulation 61-67.

1. Force mains shall be laid at least 10 feet horizontally from any existing or proposed potable water main. The distance shall be measured edge to edge. In cases where it is not practical to maintain a 10 foot separation, SCDHEC may allow deviation on a case-by-case basis, if supported by data from the Design Engineer.

2. Force mains crossing potable water mains shall be laid to provide a minimum vertical separation of 18 inches between the outside of the potable water main and the outside of the sewer. This shall be the case whether the potable water main is above or below the sewer, but preferably above the sewer. Where a new sewer line crosses a new potable water main, a full length of pipe shall be used for both the sewer line and potable water main and the crossing shall be arranged so that the joints of each line shall be as far as possible from the point of crossing and each other. Where a potable water main crosses under a sewer, adequate structural support shall be provided for the sewer line to prevent damage to the potable water main while maintaining line and grade.

3. When it is impossible to obtain the distances specified above, SCDHEC may allow an alternative design. Consult SCDHEC's "Standards for Wastewater Facility Construction" for guidelines.

F. Tracer Wire: Install a continuous 12 gauge insulated tracing wire along all pressure pipelines (Refer to Sewer Panel 6). The wire shall be secured to the pipeline at 10' intervals. Access to the wire shall be provided at the pump station, air relief/vacuum breaker valves, and terminating manhole. Color of wire insulation shall be green. Maximum tracing wire length shall be 1000' without terminating in a valve box or intermediate detector site (Dummy Valve Box). Intermediate detector sites shall not be located in pavement areas. Place precast circular concrete collar over dummy valve box (Ref. Sewer Panel 6). Splices shall be kept to a minimum, but if required, shall be made with an underground connector rated for direct burial service. Should the type of pipe material transition to iron pipe, the tracing wire shall be terminated at an intermediate detector site. Force mains that are installed by a trenchless method (i.e. directional drill), four #14 wires shall be installed with the pipe and connected to the tracer wire at both ends or cad welded to the existing iron pipe at both ends.

Prior to scheduling a final inspection with BCWS, the Contractor shall demonstrate that the locator wire functions properly by providing BCWS with a certificate of continuity test from a third party.

G. BCWS will chain and lock the valves on the discharge piping in the closed position during construction. Removal of the chain and lock must be done in the presence of a BCWS representative when necessary.

3.05 THRUST RESTRAINT

A. All sections of sanitary sewer force main identified as "PVC" or "DI" on the Drawings is to be constructed of standard pipe and ductile iron fittings as specified in this Section. All associated plugs, caps, valves, tees, branches, and bends utilized in conjunction with PVC or DI force mains are to be restrained.

B. All sections of force main that are to be restrained in accordance with BCWS standards are to be clearly identified on both the construction and record drawings.

C. Provide additional thrust restraint at any other points where, in the opinion of the Engineer, hydraulic thrust may develop (Refer to Common Panel 3).

D. Ductile Iron Push-on Joint Pipe, Fittings, and Valves – U.S. Pipe FIELD LOK® Gasket; American Cast Iron Pipe Company Fast-Grip® Gasket; or equal as approved by BCWS.

E. Ductile Iron Mechanical Joint Pipe, Fittings, and Valves – Provide retainer glands (Megalug®, Series 1100 manufactured by EBAA Iron, or equal approved by BCWS) where required and/or shown on the Drawings. Retainer glands shall be installed in accordance with the manufacturer's recommendations.

F. PVC Push-on Joint Pipe, Fittings, and Valves – EBAA Iron Sales, Inc. Series 2000PV, Series 2800, Series 1600, Series 2500; or equal as approved by BCWS.

3.06 INSTALLATION - BORE AND JACK CASING

A. Where required by SCDOT permit, install steel casing pipe under highway using the bore and jack, or similar tunneling method that has been reviewed and approved by the Engineer. Thread and support ductile iron sewer pipe through casing at location and grades as indicated on the Drawings. Refer to the additional specifications on steel casing pipe in Section 02730.

3.07 INSTALLATION – AIR RELEASE VALVES AND MANHOLES

A. Automatic non-slam air release valves shall be placed at high points in the sewer force main to prevent air locking.

B. Install non-slam air release valves in precast manholes with frames and covers.

C. Install valves and manholes as shown on the Drawings or as directed by the Engineer. Clean valve interiors of all foreign matter before installation. Inspect valve in both opened and closed positions to ensure that all parts are in proper working condition.

D. Provide thrust restraint as specified in paragraph 3.5 of this Section.

E. Coat air release manholes and pipes inside air release manholes with Raven 405 Epoxy Coating at 120 mils nominal thickness.

3.08 INSTALLATION – PLUG VALVES

A. Install plug valves on force mains in lieu of gate valves.

3.09 PAVEMENT REPAIR AND REPLACEMENT

A. Replace or repair all surface courses on roads and routes, sidewalks and driveways that are removed or damaged in the construction of this project. Repair or replace pavements in accordance with S. C. Department of Transportation's Standard Specifications for Highway Construction.

B. Repair cuts transverse to surfaced roadways and driveways using a minimum of eight inch thick stabilized aggregate base course topped with (1) 200 lbs./sq. yd. of hot plant mix asphaltic concrete or (2) six inch thick cast-in-place concrete, as appropriate to match pre-existing condition and as required by the Engineer and permitting agency.

C. Maintain all replaced or repaired bituminous paving and concrete paving, for a period of two (2) year following acceptance of the project.

D. Maintain traffic on all roads and routes which must be crossed by sewer lines. If the open cut method is used, either (1) make two separate cuts to allow one lane open to traffic at all times, or (2) provide suitable detour.

E. Place excavated material on the traffic side of the trench forming a barrier between vehicular traffic and the construction trench. Otherwise, utilize moveable barricades, which can be relocated as the work progresses.

F. Provide construction signs, guards, flashing warning lights and flagmen in accordance with the S.C. Department of Transportation’s regulations and guidelines.

3.10 PROTECTION OF FINISHED WORK

A. Protect pipe and aggregate cover from damage or displacement until backfilling operation is in progress.

## 3.11 WORK WITHIN PUBLIC RIGHT OF WAY

Work in public rights of way shall be in accordance with the encroachment permit issued by the controlling entity. All work in the rights of way shall be complete within 500 feet of the forward progress unless the encroachment permit dictates more stringent requirements. The Engineer will suspend work if the 500 feet requirement is not met. In determining this level of completion the Engineer will evaluate the final grading and erosion and sedimentation compliance.

- END OF SECTION -

SECTION 02734

SANITARY SEWER FORCE MAIN TESTING

PART 1 -- GENERAL

1.01 SECTION INCLUDES

A. Pressure Test

1.02 REGULATORY REQUIREMENTS

A. Conform to SCDHEC Standards for Wastewater Facility Construction: R.61-67.

PART 2 -- EXECUTION

2.01 GENERAL

A. Schedule inspections with BCWS at least 72 hours in advance.

B. Compaction testing will be performed in accordance with ASTM D1557.

2.02 PRESSURE TEST

A. Pressure test all sections of the force main in accordance with AWWA C600 (DIP) or AWWA C-605 (PVC).

B. Provide temporary blocking, bulkheads, flanges and plugs as necessary to assure all new pipes, valves and appurtenances will be pressure tested.

C. Before applying test pressure, completely expel air from the force mains and all appurtenances. Utilize non- slam air release valves, as shown on the Drawings, to expel air as line is filled with water.

D. Any use of BCWS water must be coordinated with BCWS. Fill pipeline slowly with water from the BCWS system. Utilize an accurate water meter and pump arrangement to pump the line to the specified test pressure.

E. Measure test pressure at the lowest point in the test segment. Maintain test pressure for a minimum of two hours. Provide a test pressure of 150 psi or 1.5 times the working pressure in the finished force main, whichever is greater.

F. Do not allow a variance in the test pressure of more than 5 psi for the test duration. If the pressure drops more than 5 psi at any time during the test period, restore the pressure to the specified test pressure. Provide an accurate pressure gauge, four inches in diameter, with a range of pressure large enough to allow the specific test pressure to fall in the middle of the range (i.e. for 150 psi test pressure need 300 psi range on gage). Face

gradations shall be at 20 psi intervals with tick marks every one psi, or equal approved by BCWS.

G. Definition of Leakage: The quantity of water that is pumped and metered into the test section to maintain test pressure within 5 psi of the specified test pressure for the test duration, plus the quantity of water required to return line to test pressure at the end of the test.

H. Test Results: Reject test section if the leakage exceeds the limits determined by the AWWA allowable leakage rate as stated in Section C605 and C600 as follows:

| Ductile Iron | PVC |
|---|---|
| $L = \frac{SD(P)^{0.5}}{148{,}000}$ | $L = \frac{ND(P)^{0.5}}{8{,}223}$ |

For the ductile iron pipe equation, “L” is the allowable leakage in gallons per hour, “S” is the length of water main tested in feet, “D” is the nominal diameter of the water main in inches, and “P” is the test pressure in pounds per square inch (psi).

For the PVC pipe equation, “L” is the allowable leakage in gallons per hour, “N” is the number of joints in the length of water main tested, “D” is the nominal diameter of the water main in inches, and “P” is the test pressure in pounds per square inch (psi).

I. If tests indicate work does not meet specified requirements, remove work, replace and retest at no cost to the Owner.

J. Locate and repair defective joints and/or pipes, and retest until the allowable test rates are within specified allowances.

- END OF SECTION -

SECTION 02737

BYPASS PUMPING

PART 1 -- GENERAL

1.01 SECTION INCLUDES

A. The design, installation and operation of the temporary pumping system(s) that will satisfy all temporary bypass pumping requirements while the work is in progress.

B. Requirements and procedures for the Contractor to demonstrate that the proposed temporary bypass pumping system is appropriate for the required temporary bypass pumping operations

1.02 GENERAL REQUIREMENTS

A. Adequate bypass pumping capability must be available at the project site at all times.

B. At no time will discharge of untreated wastewater be permitted.

1.03 RELATED SECTIONS

A. Section 01510 – Temporary Utilities

B. Section 02733 – Sanitary Sewer Force Mains

1.04 REFERENCES

A. NASSCO – Manual of Practice – Wastewater Collections Systems.

B. NASSCO – Specification Guidelines – Wastewater Collection Systems Maintenance & Rehabilitation.

C. NASSCO – Inspector Handbook for Sewer Collection System Maintenance & Rehabilitation.

D. USEPA – Handbook for Sewer System Rehabilitation and Rehabilitation.

1.05 DEFINITIONS

A. Refer to NASSCO – Specification Guidelines – Wastewater Collection Systems Maintenance & Rehabilitation.

B. Refer to NASSCO – Inspector Handbook for Sewer Collection System Maintenance & Rehabilitation.

1.06 SUBMITTALS FOR REVIEW

A. Submit a detailed description of the proposed temporary bypass pumping system(s) meeting the requirements of all codes and regulatory agencies having jurisdiction. Include the following listed equipment:

1. Provide fully automatic self-priming pump units that do not require the use of foot-valves or vacuum pumps in the priming system. The pumps may be electric or diesel powered. All pumps used must be constructed to allow dry running for long periods of time to accommodate the cyclical nature of sewer flows.

2. Provide necessary stop/start controls for each pump.

3. Include one stand-by pump of each size to be maintained on site. Back-up pumps shall be on-line, isolated from the primary system by a valve.

B. A detailed plan and description outlining all provisions and precautions to be taken by the Contractor regarding the handling of existing wastewater flows during temporary bypass pumping operations. Plan must be specific and complete, and as a minimum, include the following:

1. Staging areas for pumps;
2. Sewer plugging method and types of plugs;
3. Number, size, material, location and method of installation of suction piping;
4. Number, size, material, method of installation and location of installation of discharge piping;
5. Bypass pump sizes, capacity, number of each size to be on site and power requirements;
6. Calculations of static lift, friction losses, and flow velocity (pump curves showing pump operating range shall be submitted);
7. Downstream discharge plan;
8. Method of protecting discharge manholes or structures from erosion and damage;
9. Thrust and restraint block sizes and locations;
10. Sections showing suction and discharge pipe depth, embedment, select fill and special backfill;
11. Method of noise control for each pump and/or generator;
12. Any temporary pipe supports and anchoring required;
13. Design plans and computation for access to bypass pumping locations indicated on the drawings;
14. Calculations for selection of bypass pumping pipe size;
15. Schedule for installation of and maintenance of bypass pumping lines;
16. Plan indicating selection location of bypass pumping line locations.

1.07 REGULATORY REQUIREMENTS

A. Conform to applicable regulations of the SCDHEC and guidelines as published in the National Association of Sewer Service Companies.

1.08 PAYMENT

A. Include payment for Bypass Pumping associated with the installation of pipe and appurtenances in the contract unit price for corresponding sewer line and manhole construction, or other corresponding payment items.

B. No separate measurement or payment will be made for Bypass Pumping.

PART 2 -- PRODUCTS

2.01 DESIGN REQUIREMENTS

A. Provide bypass-pumping systems with sufficient capacity to pump peak flows and with the capacity to be operated 24 hours per day. Provide all pipeline plugs, pumps of adequate size to handle peak flow, and temporary discharge piping to ensure that the total flow of the main can be safely diverted around the work area.

B. Provide adequate standby equipment ready for immediate operation and use in the event of an emergency or breakdown. Install one standby pump for each size pump utilized at the mainline flow bypassing locations, ready for use in the event of primary pump failure.

C. Provide bypass-pumping systems capable of bypassing the flow around the work area and of releasing any amount of flow up to full available flow into the work area as necessary for satisfactory performances of work.

2.02 PERFORMANCE REQUIREMENTS

A. It is essential to the operation of the existing sewerage collection system that there be no interruption in the flow of sewage throughout the duration of the project. To this end and to avoid interference with the construction work, provide, maintain, and operate all temporary facilities necessary bypass the work area. Temporary facilities include dams, plugs, pumping equipment (both primary and back-up units as required), conduits, all necessary power, and all other necessary labor and equipment.

B. Assume responsibility for the design, installation and operation of the temporary pumping system. Assure that the bypass system meets the requirements of all codes and regulatory agencies having jurisdiction.

C. Provide all necessary means to safely convey the sewage past the work area. The Contractor will not be permitted to stop or impede the main flows under any circumstances.

D. Maintain sewer flow around the work area in a manner that will not cause surcharging

of sewers, damage to sewers, and that will protect public and private property from damage and flooding.

E. Protect water resources, wetlands and other natural resources.

2.03 TESTING

A. Perform leakage and pressure tests of the bypass pumping discharge piping using clean water prior to actual operation. Provide the engineer with 24 hours notice prior to testing.

2.04 INSPECTION

A. Inspect temporary bypass pumping systems a minimum of every two hours to ensure that the system is working correctly.

2.05 MAINTENANCE SERVICE

A. Insure that the temporary pumping system is properly maintained and a responsible operator is on hand at all times when pumps are operating.

2.06 EXTRA MATERIALS

A. Keep essential spare parts for pumps and piping on site as required.

B. Maintain adequate hoisting equipment for each pump and accessories on the site.

2.07 PRECAUTIONS

A. Be responsible for locating existing utilities in the area of temporary bypass operations and the location of the bypass pipelines. Locate bypass pipelines to minimize any disturbance to existing utilities. Coordinate the use of existing utilities and the location of the bypass pumps and pipeline with the Owner and the Engineer.

B. Protect all existing utilities from damage that may be inflicted during temporary bypass pumping operations. Be responsible for all physical damage to existing utilities caused by human or mechanical failure.

PART 3 -- EXECUTION

3.01 SETUP

A. Remove manhole sections or make connections to the existing sewer and construct temporary bypass pumping structures only at the access location indicated on the Drawings and as may be required to provide adequate suction conduit.

3.02 TEMPORARY PLUGGING OF LINES

A. Incorporate a primary and secondary plugging device for plugging or blocking of sewage flows. When plugging or blocking is no longer needed for performance and acceptance of work, remove plugging or blocking in a manner that permits the sewage flow to slowly return to normal. Avoid surges, surcharging, and other major disturbances downstream.

3.03 CONFINED SPACE ENTRY

A. Exercise appropriate caution when working inside manhole or any confined space. Comply with OSHA requirements when working in the presence of sewer gases, combustible or oxygen-deficient atmospheres commonly found in confined spaces.

3.04 LOCATION OF PIPELINES

A. The installation of the bypass pipelines is prohibited in all salt marsh/wetland areas. Pipelines must be located off streets and sidewalks and on shoulders of the roads. When the bypass pipeline crosses local streets and private driveways, the contractor must place the bypass pipelines in trenches and cover with temporary pavement.

3.05 COMPLETION OF WORK

A. Upon completion of the temporary bypass pumping operations, remove all the piping and restore all paved surfaces and disturbed property to pre-construction condition.

**-** END OF SECTION -

SECTION 02825

EXTRUDED POLYVINYL CHLORIDE (PVC) FENCING

PART 1 -- GENERAL

1.01 SECTION INCLUDES

A. Drawings and general provisions of the contract apply to this section.

B. Polyvinyl chloride (PVC) fence, gate components, and accessories.

C. Gate hardware.

D. Reinforcing steel for concrete-filled, reinforced fence posts.

E. Concrete for post footings and for concrete filled reinforced fence posts.

1.02 RELATED SECTIONS

A. Section 02200 - Earthwork.

B. Section 02500 - Paving and Surfacing.

C. Section 03300 - Cast-in-Place concrete.

1.03 REFERENCES

A. ASTM A615 - Deformed and Plain Billet Steel Bars for Concrete Reinforcement.

B. ASTM C33 - Concrete Aggregates.

C. ASTM C150 - Portland Cement.

D. ASTM C387 - Standard Specification for Packaged, Dry, Combined Materials for Mortar and Concrete.

E. ASTM D1784 - Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.

1.04 DEFINITIONS

A. Posts are the vertical structure support members of the fence.

B. Rails are the horizontal structural support members of the fence or gate frame.

C. Pickets are the vertical, non-structural members between bottom and top rails.

D. Gate Uprights are the vertical structural support members of the gate frame.

1.05 SUBMITTALS FOR REVIEW

A. Section 01300 - Submittals.

B. Product Data: In the form of manufacturer's technical data, specifications, and installations for fence, posts, gate uprights, post caps, gates, gate hardware and accessories.

C. Samples for verification of PVC color in form of 3-inch lengths of actual product to be used in color selection.

D. Shop Drawings showing fence design and gate layout and design.

1.06 QUALITY ASSURANCE

A. Installer Qualifications: Engage an experienced installer who has at least three years experience and has completed at least five PVC fence projects with same material and of similar scope to that indicated for this project with a successful construction record of in-service performance.

B. Single-Source Responsibility: Obtain PVC fences and gates, including accessories, fittings, and fastenings, from a single source.

1.07 PROJECT CONDITIONS

A. Field Measurements: Verify layout information for fences and gates shown on the drawings in relation to the property survey and existing structures. Verify dimensions by field measurements.

1.08 WARRANTY

A. Manufacturer's Warranty: Provide lifetime non-prorated limited warranty.

PART 2 -- PRODUCTS

2.01 FENCE MATERIALS

A. General: Provide PVC fence materials recognized to be of type indicated and tested to show compliance with indicated performances.

B. Manufacturer: Master Halco, Inc. 110 E. La Habra Blvd., La Habra, California 90631 (Phone: 1-800-883-8384). No substitutes.

C. PVC FENCE:
Style: Legend Series Vinyl Fence Universal III Style with steel reinforcement.
Height: 6 feet.

2.02 POLYVINYL CHLORIDE (PVC) FENCE COMPONENTS

A. General: Posts, rails, pickets, gate uprights, post caps, and accessories shall be of high impact, Ultra Violet (U.V.) resistant, rigid PVC, and shall comply with ASTM D1784, Class 14344B and have the following characteristics:

| | |
|---|---|
| Specific Gravity (+/- 0.02) | 1.4 |
| Using 0.125 specimen Izod impact ft. lbs./in. notch | 23.0 |
| Tensile strength, PSI | 6,910 |
| Tensile modulus, PSI | 336,000 |
| Flexural yield strength, PSI | 10,104 |
| Flexural modulus, PSI | 385,000 |
| DTUL at 264 PSI | 67°C |

B. Pickets: (Size) 7/8” x 6”

C. Rails: (Size) 6” x 3½”

D. Line and Corner Posts: (Size) 6 inch (with steel reinforcement).

E. Post & Gate Caps: Pyramid internal post & gate caps. (i.e. all vertical elements shall be capped)

F. Color: White.

G. Gate Uprights: As recommended by Manufacturer and as indicated on shop drawings.

H. Accessories: Manufacturers’ standard gate brace, screw caps, rail end reinforcers, and other accessories as required.

2.03 MISCELLANEOUS MATERIALS

A. Stiffener Channels: Galvanized steel structural channel. Configure channels for concealed installation within PVC rails with pre-drilled holes for drainage. Aluminum extruded channel available upon request.

1. Cross Section: 3.00" x 3.00" x 1.500" hourglass shape to grip picket.
2. Thickness: 0.040 Gauge (minimum)

B. Fasteners and Anchorage: Stainless Steel. All fasteners shall be concealed or colored heads to match. Provide sizes as recommended by fence manufacturer.

C. PVC Cement: As recommended by fence manufacturer.

2.04 GATES AND ACCESSORIES

A. General:
1. Gate Types, Opening Widths and Directions of Operation: As indicated on Drawings.
2. Factory assemble gates.
3. Design gates for operation by one person.

4. Fabricate gates to permit 180 degree swing.

B. Gate Hardware: Center gate stop and drop rod; two 180-degree non lift-off type gate hinges (color: black) per leaf, latch and hardware for padlock, and padlock keyed to Owner's standard.

2.05 CONCRETE

A. Concrete: Provide concrete consisting of Portland cement per ASTM C150, aggregates per ASTM C33, and potable water. Mix materials to obtain concrete with a minimum 28-day compressive strength of 4,000 psi. Use at least four sacks of cement per cubic yard, 1-inch maximum size aggregate, 3-inch maximum slump. Use ½-inch maximum size aggregate in post where required.

B. Packages Concrete Mix: Mix dry-packaged normal-weight concrete conforming to ASTM C387 with clean water to obtain a 2 to 3 inch slump.

2.06 REINFORCEMENT FOR POSTS

A. Aluminum Stiffeners:

1. Aluminum stiffeners shall be provided as per manufacturer's specification.

PART 3 -- EXECUTION

3.01 EXAMINATION

A. Verify areas to receive fencing are completed to final grades and elevations.

B. Ensure property lines and legal boundaries of work are clearly established.

3.02 INSTALLATION

A. Install fence in compliance with manufacturer's written instructions. During installation, PVC components shall be carefully handled and stored to avoid contact with abrasive surfaces. Install components in sequence as recommended by fence manufacturer.

B. Set gate posts for gate opening specified in the construction drawings as per manufacturer's instructions. Posts shall be placed 36" (minimum) in the ground and set in concrete. An aluminum stiffener shall be installed in each post according to manufacturer's recommendations.

C. Place assembled fence sections into position and slide rails into posts. The rails are secured into posts by tabs which are notched into the rails and catch on the inside wall of the post.

D. Check each post for vertical and top alignment, and maintain in position during placement and finishing operation.

3.03 GATE INSTALLATION

A. Install gates plumb, level and secure using bolt-on hardware supplied by the manufacturer.

B. Adjust hardware for smooth operation.

3.04 ACCESSORIES

A. Install post caps and other accessories to complete fence.

3.05 CLEANING

A. Clean up debris and unused material and remove from site. Remove all traces of dirt and soiled areas from completed fence.

3.06 DEMONSTRATION

A Instruct the Owner's personnel on proper operation and maintenance of fence components.

- END OF SECTION -

SECTION 02910

FINAL GRADING AND LANDSCAPING

## PART 1 -- GENERAL

### 1.01 THE REQUIREMENT

A. Furnish all labor, equipment, and materials necessary for final grading, topsoiling, seeding, and miscellaneous site work not included under other Sections, but required to complete the work as shown on the Drawings and specified herein. Under this Section, all areas of the project site disturbed by excavation, materials storage, temporary roads, etc., shall be reseeded as specified herein.

### 1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 02276 - Erosion and Sedimentation Control.

B. Section 02500 - Surface Restoration.

### 1.03 SUBMITTALS

A. Submit the following in accordance with Section 01300, Submittals.

1. Product Data
2. Certification of all materials
3. Three (3) copies of composition and germination certification and of test results for grass seed.

## PART 2 -- PRODUCTS

### 2.01 CONTRACTOR'S RESPONSIBILITIES

A. Furnish and submit certification for the materials used as specified in the General Conditions, Division 1 and Division 2.

### 2.02 TOPSOIL

A. Upon completion and approval of the rough grading, the Contractor shall place the topsoil over all areas disturbed during construction under any contract except those areas which will be paved, graveled or rip rapped. Topsoil shall not be placed in a frozen or muddy condition and shall contain no toxic materials harmful to grass growth. Topsoil shall be as defined under Section 02200, Earthwork.

### 2.03 WATER

A. Water shall be furnished to the Contractor by the Owner from existing facilities as directed by the Engineer.
B. The Contractor shall furnish all hoses and connections necessary to complete the landscaping work.

2.04 FERTILIZER

A. Fertilizer shall be a complete commercial fertilizer with components derived from commercial sources. Fertilizer analysis shall be determined from field soil sampling in appropriate number taken by the Contractor and analyzed by the S.C. Department of Agriculture or other independent laboratory. Contractor shall furnish fertilizer in accordance with the recommendations of the S.C. Department of Agriculture.

B. One-quarter of the Nitrogen shall be in the form of nitrates, one-quarter in the form of ammonia salts, and one-half in the form of natural organic Nitrogen. Available Phosphoric Acid shall be free from superphosphate, bone, or tankage. Potash shall be Sulphate of Potash. Elements shall conform to the standards of Association of Official Agricultural Chemists.

C. Fertilizer shall be delivered in standard size bags marked with the weight, analysis of contents, and the name of the manufacturer. Fertilizer shall be stored in weatherproof storage areas and in such a manner that its effectiveness will not be impaired.

2.05 LIME

A. At least 50% shall pass a No. 200 U.S.S. mesh sieve. At least 90% shall pass a No. 100 U.S.S. mesh sieve and 100% shall pass a No. 10 U.S.S. mesh sieve. Total carbonates shall not be less than 80% or 44.8% Calcium Oxide equivalent. For the purpose of calculation, total carbonates shall be considered as Calcium Carbonate.

2.06 GRASS SEED

A. The Contractor shall furnish the kinds and amounts of seed to be seeded in all areas disturbed by the construction work. All seed shall be labeled to show that it meets the requirements of the South Carolina Seed Law. All seed must have been tested within six (6) months immediately preceding the planting of such material on the job.

B. The inoculant for treating legume seed shall be a pure culture of nitrogen-fixing bacteria prepared specifically for the species. Inoculants shall not be used later than the date indicated on the container. The quality of the seed shall conform to the following:

| Type | Minimum Seed Purity (%) | Minimum Germination (%) | Maximum Weed Seed (%) |
|---|---|---|---|
| Common Bermuda | 98 | 85 | 0.25 |
| Hybrid Rye | 98 | 85 | 0.10 |
| Bahia Grass | 98 | 85 | 0.25 |
| Millet | 98 | 85 | 0.50 |
| Sericea Lespedeza | 98 | 85 | 0.50 |

| | | | |
|---|---|---|---|
| Scarified Unscarified | 98 | 85 | 0.50 |

C. Scarified Lespedeza may contain 20% hard seed and unscarified 50% hard seed. Seed containing prohibited noxious weed seed shall not be accepted. Seed shall be in conformance with S.C. Seed Law restrictions for restricted noxious weeds.

D. Seed mixtures to be used on the project shall be as shown on the Drawings.

2.07 WOOD CELLULOSE FIBER MULCH

A. For use in hydroseeding grass seed in combination with fertilizers and other approved additions, shall consist of especially prepared wood cellulose fibers such as "Conwed", "Mat-Fiber", or equal, and have no growth or germination inhibiting factors, and be dyed green.

B. The wood cellulose fiber shall have the additional characteristic of dispersing rapidly in water to form a homogeneous slurry and remain in such state when agitated in the hydraulic mulching unit, or adequate equal, with the specified materials.

C. When applied, the wood cellulose fiber with additives will form an absorptive mat but not a plant inhibiting membrane, which will allow moisture, natural or mechanical, to percolate into underlying soil.

D. The mulch shall be supplied, compressed in packages containing 50 pounds of material having an equilibrium air dry moisture content at time of manufacture of 12% plus or minus 3%. Wood cellulose fiber mulch shall be stored in a weatherproof storage area and in such a manner that effectiveness will not be impaired.

2.08 STRAW MULCH

A. Straw used for mulch shall be small grain hay. Hay shall be undamaged, air dry, threshed straw, free of undesirable weed seed. Straw mulch is not required for seeded areas treated with a temporary soil stabilizer.

2.09 TEMPORARY SOIL STABILIZER

A. The temporary agent for soil erosion control shall consist of an especially prepared highly concentrated powder which, when mixed with water, forms a thick liquid such as "Enviroseal 2001" by Enviroseal Corporation, "Terra Control" by Quattro Environmental, Inc., or "CHEM-CRETE ECO-110" by International CHEM-CRETE Corporation, and having no growth or germination inhibiting factors. The agent shall be used for hydroseeding grass seed in combination with other approved amendments resulting in a highly viscous slurry which, when sprayed directly on the soil, forms a gelatinous crust.

2.10 ROLLED EROSION CONTROL PRODUCTS

A. The rolled erosion control products (RECPs) shall be as specified in Section 02276 - Erosion and Sedimentation Control.

2.11 RIPRAP AND HERBICIDES

A. Furnish and install sufficient quantity of landscape gravel or riprap to cover over the ground to a minimum 4-inch depth for gravel and 24-inch depth for riprap, unless otherwise noted, or indicated on the Drawings. Also furnish and apply an approved herbicide to the subgrade surface just prior to installing the landscape gravel or riprap.

B. During placing, the stone shall be graded so that the smaller stones are uniformly distributed through the mass. The Contractor may place the stone by mechanical methods, augmented by hand placing where necessary or ordered by the Engineer. The placed riprap shall form a properly graded, dense, neat layer of stone.

C. All topsoil and vegetative matter shall be removed from the subgrade surfaces prior to the application of the weed killer (herbicide) and to the placement of landscape gravel or riprap. Apply commercial-type herbicide as preemergence control of miscellaneous grasses and broadleaf weeds in granular or liquid form such as "Treflan", "Dymid", or equal. Methods and rates of application shall be in strict compliance to manufacturer's directions and acceptable to the Engineer.

D. The herbicide selected shall be safe for use around ornamental plantings, have long-lasting weed control, and shall be resistant to leaching away under excessive rainfall.

E. A second application of the herbicide shall be made on the surface of the landscape gravel or riprap sometime after the first six (6) months, but not later than 12-months. Same methods and rates apply as specified previously.

PART 3 -- EXECUTION

3.01 GRADING

A. After approval of the rough grading, the Contractor shall commence his preparations of the subgrade for the various major conditions of the work as follows:

1. Bare soil for riprap area at subgrade (24-inches below final grade, or as directed by the Engineer).

2. Topsoil for lawn and road shoulder seed area - scarify 2-inch depth of subgrade (4-inches below final grade) prior to placing topsoil.

B. Final surface grading of the topsoiled, landscape graveled, and riprapped areas shall be mechanically raked or hand raked to an even finished surface alignment.

3.02 TOPSOIL

A. Topsoil shall be spread in place for quantity required for lawn and road shoulder seed areas at 4-inch consolidated depth, and sufficient quantity for certain plant beds and backfill for shrubs and trees as specified.

3.03 SEEDBED PREPARATION

A. Contractor shall prepare all areas to receive temporary or permanent seeding measures prior to planting.

B. Topsoil shall be placed in areas to be seeded and roughened with tracked equipment or other suitable measures. Slopes steeper than 3:1 may be roughened by grooving, furrowing, tracking, or stairstep grading. Slopes flatter than 3:1 should be grooved by disking, harrowing, raking, operating planting equipment on the contour.

C. Soil amendments including, but not limited to, lime and fertilizer shall be spread as necessary, and at the rates specified in this Section. Seeding shall be as per the type and rates specified in this Section. Seed shall be broadcast as soon as possible following roughening, before surface has been sealed by rainfall.

3.04 HYDROSEEDING AND GRASS

A. The Contractor shall grow a stand of grass by hydroseeding method on all disturbed areas. The Contractor shall be responsible for the satisfactory growth of grass throughout the period of the one-year guarantee.

B. The Contractor's work shall include the preparation of the topsoil and bare soil seed bed, application of fertilizer, limestone, mulching, inoculant, temporary soil stabilizer, watering, and all other operations necessary to provide a satisfactory growth of sod at the end of the one-year maintenance period. Areas without satisfactory sod at the end of one (1) year shall be replanted until satisfactory growth is obtained and acceptable to the Engineer.

C. All areas to be seeded shall be done by the hydraulic seeding method including all additives and amendments required. A "Reinco", "Finn", or "Bowie" type hydromulcher with adjustable nozzles and extension hoses, or equal, shall be utilized. General capacity of tank should range from 500 to 2,500 gallons, or as approved by the Engineer.

D. Hydraulic seeding shall be carried out in three steps. Step one shall consist of the application of lime. In step two the seed mixture shall be mixed with the fertilizer, wood cellulose fiber mulch, and any required inoculants and applied to the seed bed. Step three shall consist of application of top dressing during the first spring or fall, whichever comes first, after step two.

E. Top dressing shall consist of a commercial grade fertilizer plus Nitrogen or other analysis as may be recommended by soil testing. Types and application rates of seed mixtures, lime, fertilizer, and wood cellulose fiber mulch, shall be as shown in the Seeding Schedule.

F. Ingredients for the mixture and steps should be dumped into a tank of water and thoroughly mixed to a homogeneous slurry and sprayed out under a minimum of 300-350 pounds pressure, in suitable proportions to accommodate the type and capacity of the hydraulic machine to be used. Applications shall be evenly sprayed over the ground surface. The Contractor shall free the topsoil of stones, roots, rubbish, and other deleterious materials and dispose of same off the site. The bare soil, except existing steep embankment area, shall be rough raked to remove stones, roots, and rubbish over 4-inches in size, and other deleterious materials and dispose of same off the site.

G. No seeding should be undertaken in windy or unfavorable weather, when the ground is too wet to rake easily, when it is in a frozen condition, or too dry. Any bare spots shown in two to three weeks shall be recultivated, fertilized at half the rate, raked, seeded, and mulched again by mechanical or hand broadcast method acceptable to the Engineer.

H. Areas that have been seeded with a temporary seed mixture shall be mowed to a height of less than 2-inches and scarified prior to seeding with the permanent seed mixture.

I. The Contractor shall provide, at his own expense, protection for all seeded areas against trespassing and damage at all times until acceptance of the work. Slopes shall be protected from damage due to erosion, settlement, and other causes and shall be repaired promptly at the Contractor's expense.

J. The Contractor shall water newly seeded areas of the lawn and road shoulder mix once a week until the grasses have germinated sufficiently to produce a healthy turf, or unless otherwise directed by the Engineer. Each watering shall provide three (3) gallons per square yard. The Contractor shall furnish all necessary hoses, sprinklers, and connections.

K. The first and second cutting of the lawn grasses only shall be done by the Contractor. All subsequent cuttings will be done by the Owner's forces in a manner specified by the Contractor.

3.05 DITCH AND SWALE EROSION PROTECTION

A. All ditches and swales indicated on the Drawings shall be lined with a rolled erosion control product (RECP). The area to be covered shall be properly graded and hydroseeded before the RECP is installed. Installation shall be in accordance with Section 02276, Erosion and Sedimentation Control.

3.06 MAINTENANCE

A. The Contractor shall be responsible for maintaining all seeded areas until 100% construction completion has been achieved. Maintenance shall include but not be limited to, annual fertilization, mowing, repair of seeded areas, irrigation, and weed control. The Contractor shall provide, at his own expense, protection for all seeded areas against trespassing and damage at all times until acceptance of the work. Slopes shall be protected from damage due to erosion, settlement, and other causes and shall be repaired promptly at the Contractor's expense.

B. Annual fertilization shall consist of an application of 500#/acre of 10-10-10 commercial grade fertilizer, or its equivalent and 60#/acre of nitrogen in early fall, or other analysis as may be determined by soil test. Annual fertilization shall be in addition to top dressing and shall be performed by the Contractor each fall season after planting until the work is substantially complete.

C. Mowing shall be scheduled so as to maintain a minimum stand height of 4-inches or as directed by the Engineer. Stand height shall be allowed to reach 8 to 10-inches prior to mowing.

D. All seeded areas shall be inspected on a regular basis and any necessary repairs or reseedings made within the planting season, if possible. If the stand should be over 60% damaged, it shall be re-established following the original seeding recommendations.

E. Weed growth shall be maintained mechanically and/or with herbicides. When chemicals are used, the Contractor shall adhere strictly to the instructions on the label of the herbicide. No herbicide shall be used without prior approval of the Engineer.

3.07 CLEANUP

A. The Contractor shall remove from the site all subsoil excavated from his work and all other debris including, but not limited to, branches, paper, and rubbish in all landscape areas, and remove temporary barricades as the work proceeds.

B. All areas shall be kept in a neat, orderly condition at all times. Prior to final acceptance, the Contractor shall clean up the entire landscaped area to the satisfaction of the Engineer.

- END OF SECTION -

SECTION 03100

CONCRETE FORMWORK

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Provide materials, labor, and equipment required for the design and construction of all concrete formwork, bracing, shoring and supports in accordance with the provisions of the Contract Documents.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 03200 - Reinforcing Steel

B. Section 03250 - Concrete Accessories

C. Section 03290 - Joints in Concrete

D. Section 03300 - Cast-in-Place Concrete

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.

1. South Carolina Building Code 2015.

2. ACI 318 - Building Code Requirements for Structural Concrete

3. ACI 301 - Specifications for Structural Concrete for Buildings

4. ACI 347 - Recommended Practice for Concrete Formwork

5. U.S. Product Standard for Concrete Forms, Class I, PS 1

6. ACI 117 - Standard Specifications for Tolerances for Concrete Construction and Materials

1.04 SUBMITTALS

A. Submit the following in accordance with Section 01300, Submittals.

1. Manufacturer's data on proposed form release agent

2. Manufacturer's data on proposed formwork system including form ties

1.05 QUALITY ASSURANCE

A. Concrete formwork shall be in accordance with ACI 301, ACI 318, and ACI 347.

PART 2 -- PRODUCTS

2.01 FORMS AND FALSEWORK

A. All forms shall be smooth surface forms unless otherwise specified.

B. Wood materials for concrete forms and falsework shall conform to the following requirements:

1. Lumber for bracing, shoring, or supporting forms shall be Douglas Fir or Southern Pine, construction grade or better, in conformance with U.S. Product Standard PS20. All lumber used for forms, shoring or bracing shall be new material.

2. Plywood for concrete formwork shall be new, waterproof, synthetic resin bonded, exterior type Douglas Fir or Southern Pine high density overlaid (HDO) plywood manufactured especially for concrete formwork and shall conform to the requirements of PS1 for Concrete Forms, Class I, and shall be edge sealed. Thickness shall be as required to support concrete at the rate it is placed, but not less than 5/8-inch thick.

C. Other form materials such as metal, fiberglass, or other acceptable material that will not adversely affect the concrete and will facilitate placement of concrete to the shape, form, line and grade indicated may be submitted to the Engineer for approval, but only materials that will produce a smooth form finish equal or better than the wood materials specified will be considered.

2.02 FORMWORK ACCESSORIES

A. Form ties shall be provided with a plastic cone or other suitable means for forming a conical hole to ensure that the form tie may be broken off back of the face of the concrete. The maximum diameter of removable cones for rod ties, or of other removable form-tie fasteners having a circular cross-section, shall not exceed 7/8-inch, and all such fasteners shall be such as to leave holes of regular shape for reaming.

B. Form ties for water-retaining structures shall have integral waterstops. Removable taper ties may be used when acceptable to the Engineer. A preformed mechanical EPDM rubber plug shall be used to seal the hole left after the removal of the taper tie. Plug shall be X-Plug by the Greenstreak Group, Inc., or approved equal. Friction fit plugs shall not be used.

C. Form release agent shall be a blend of natural and synthetic chemicals that employs a chemical reaction to provide quick, easy and clean release of concrete from forms. It shall not stain the concrete and shall leave the concrete with a paintable surface. Formulation of the form release agent shall be such that it would minimize formation of "bug holes" in cast-in-place concrete.

PART 3 -- EXECUTION

3.01 FORM DESIGN

A. Forms and falsework shall be designed for total dead load, plus all construction live load as outlined in ACI 347. Design and engineering of formwork and safety considerations during construction shall be the responsibility of the Contractor.

B. Forms shall be of sufficient strength and rigidity to maintain their position and shape under the loads and operations incident to placing and vibrating the concrete. The maximum deflection of facing materials reflected in concrete surfaces exposed to view shall be 1/240 of the span between structural members.

C. All forms shall be designed for predetermined placing rates per hour, considering expected air temperatures and setting rates.

3.02 CONSTRUCTION

A. The type, size, quality, and strength of all materials from which forms are made shall be subject to the approval of the Engineer. No falsework or forms shall be used which are not clean and suitable. Deformed, broken or defective falsework and forms shall be removed from the work.

B. Forms shall be smooth and free from surface irregularities. Suitable and effective means shall be provided on all forms for holding adjacent edges and ends of panels and sections tightly together and in accurate alignment so as to prevent the formation of ridges, fins, offsets, or similar surface defects in the finished concrete. Joints between the forms shall be sealed to eliminate any irregularities. The arrangement of the facing material shall be orderly and symmetrical, with the number of seams kept to a practical minimum.

C. Forms shall be true to line and grade, and shall be sufficiently rigid to prevent displacement and sagging between supports. Curved forms shall be used for curved and circular structures. Straight panels joined at angles will not be acceptable for forming curved structures. Forms shall be properly braced or tied together to maintain their position and shape under a load of freshly-placed concrete. Facing material shall be supported with studs or other backing which shall prevent both visible deflection marks in the concrete and deflections beyond the tolerances specified.

D. Forms shall be mortar tight so as to prevent the loss of water, cement and fines during placing and vibrating of the concrete. Specifically, the bottom of wall forms that rest on concrete footings or slabs shall be provided with a gasket to prevent loss of fines and paste during placement and vibration of concrete. Such gasket may be a 1 to 1-1/2 inch diameter polyethylene rod held in position to the underside of the wall form.

E. All vertical surfaces of concrete members shall be formed, and side forms shall be provided for all footings, slab edges and grade beams, except where placement of the concrete against the ground is called for on the Drawings. Not less than 1-inch of concrete shall be added to the thickness of the concrete member as shown where concrete is permitted to be placed against trimmed ground in lieu of forms. Such permission will be granted only for members of comparatively limited height and where the character of the ground is such that

it can be trimmed to the required lines and will stand securely without caving or sloughing until the concrete has been placed.

F. All forms shall be constructed in such a manner that they can be removed without hammering or prying against the concrete. Wood forms shall be constructed for wall openings to facilitate loosening and to counteract swelling of the forms.

G. Adequate clean-out holes shall be provided at the bottom of each lift of forms. Temporary openings shall be provided at the base of column forms and wall forms and at other points to facilitate cleaning and observation immediately before the concrete is deposited. The size, number and location of such clean-outs shall be as acceptable to the Engineer.

H. Construction joints shall not be permitted at locations other than those shown or specified, except as may be acceptable to the Engineer. When a second lift is placed on hardened concrete, special precautions shall be taken in the way of the number, location and tightening of ties at the top of the old lift and bottom of the new to prevent any unsatisfactory effect whatsoever on the concrete. For flush surfaces at construction joints exposed to view, the contact surface of the form sheathing over the hardened concrete in the previous placement shall be lapped by not more than 1 inch. Forms shall be held against hardened concrete to prevent offset or loss of mortar at construction joints and to maintain a true surface.

I. The formwork shall be cambered to compensate for anticipated deflections in the formwork due to the weight and pressure of the fresh concrete and due to construction loads. Set forms and intermediate screed strips for slabs accurately to produce the designated elevations and contours of the finished surface. Ensure that edge forms and screed strips are sufficiently strong to support vibrating screeds or roller pipe screeds if the nature of the finish specified requires the use of such equipment. When formwork is cambered, set screeds to a like camber to maintain the proper concrete thickness.

J. Positive means of adjustment (wedges or jacks) for shores and struts shall be provided and all settlement shall be taken up during concrete placing operation. Shores and struts shall be securely braced against lateral deflections. Wedges shall be fastened firmly in place after final adjustment of forms prior to concrete placement. Formwork shall be anchored to shores or other supporting surfaces or members to prevent upward or lateral movement of any part of the formwork system during concrete placement. If adequate foundation for shores cannot be secured, trussed supports shall be provided.

K. Runways shall be provided for moving equipment with struts or legs. Runways shall be supported directly on the formwork or structural member without resting on the reinforcing steel.

3.03 TOLERANCES

A. Unless otherwise indicated in the Contract Documents, formwork shall be constructed so that the concrete surfaces will conform to the tolerance limits listed in ACI 117.

B. Structural framing of reinforced concrete around elevators and stairways shall be accurately plumbed and located within 1/4 in. tolerance from established dimensions.

C. The Contractor shall establish and maintain in an undisturbed condition and until final completion and acceptance of the project, sufficient control points and bench marks to be used for reference purposes to check tolerances. Plumb and string lines shall be installed before concrete placement and shall be maintained during placement. Such lines shall be used by Contractor's personnel and by the Engineer and shall be in sufficient number and properly installed. During concrete placement, the Contractor shall continually monitor plumb and string line form positions and immediately correct deficiencies.

D. Regardless of the tolerances specified, no portion of the building shall extend beyond the legal boundary of the building.

3.04 FORM ACCESSORIES

A. Suitable moldings shall be placed to bevel or round all exposed corners and edges of beams, columns, walls, slabs, and equipment pads. Chamfers shall be 3/4 inch unless otherwise noted.

B. Form ties shall be so constructed that the ends, or end fasteners, can be removed without causing appreciable spalling at the faces of the concrete. After ends, or end fasteners of form ties have been removed, the embedded portion of the ties shall terminate not less than 2 inches from the formed face of the concrete that is exposed to water or enclosed surfaces above the water surface, and not less than 1 inch from the formed face of all other concrete. Holes left by the removal of form tie cones shall be reamed with suitable toothed reamers so as to leave the surface of the holes clean and rough before being filled with mortar as specified in Section 03350 - Concrete Finishing. No form-tying device or part thereof, other than metal, shall be left embedded in the concrete. Ties shall not be removed in such manner as to leave a hole extending through the interior of the concrete member. The use of snap-ties which cause spalling of the concrete upon form stripping or tie removal will not be permitted. No snap ties shall be broken off until the concrete is at least three days old. If steel panel forms are used, rubber grommets shall be provided where the ties pass through the form in order to prevent loss of cement paste.

3.05 APPLICATION - FORM RELEASE AGENT

A. Forms for concrete surfaces that will not be subsequently waterproofed shall be coated with a form release agent. Form release agent shall be applied on formwork in accordance with manufacturer's recommendations.

3.06 INSERTS AND EMBEDDED ITEMS

A. Sleeves, pipe stubs, inserts, anchors, expansion joint material, waterstops, and other embedded items shall be positioned accurately and supported against displacement prior to concreting. Voids in sleeves, inserts, and anchor slots shall be filled temporarily with readily removable material to prevent the entry of concrete into the voids.

3.07 FORM CLEANING AND REUSE

A. The inner faces of all forms shall be thoroughly cleaned prior to concreting. Forms may be reused only if in good condition and only if acceptable to the Engineer. Light sanding between uses will be required wherever necessary to obtain uniform surface texture.

Unused tie rod holes in forms shall be covered with metal caps or shall be filled by other methods acceptable to the Engineer.

3.08 FORM REMOVAL AND SHORING

A. Forms shall not be disturbed until the concrete has attained sufficient strength. Sufficient strength shall be demonstrated by structural analysis considering proposed loads, strength of forming and shoring system, and concrete strength data. Shoring shall not be removed until the supported member has acquired sufficient strength to support its weight and the load upon it. Members subject to additional loads during construction shall be adequately shored to sustain all resulting stresses. Forms shall be removed in such manner as not to impair safety and serviceability of the structure. All concrete to be exposed by form removal shall have sufficient strength not to be damaged thereby.

B. Provided the strength requirements specified above have been met and subject to the Engineer's approval, forms may be removed at the following minimum times. The Contractor shall assume full responsibility for the strength of all such components from which forms are removed prior to the concrete attaining its full design compressive strength. Shoring may be required at the option of the Engineer beyond these periods.

**Ambient Temperature (°F.) During Concrete Placement**

| | Over 95° | 70°-95° | 60°-70° | 50°-60° | Below 50° |
|---|---|---|---|---|---|
| Walls | 5 days | 2 days | 2 days | 3 days | Do not remove until directed by Engineer (7 days minimum) |
| Columns | 7 days | 2 days | 3 days | 4 days | |
| Beam Soffits | 10 days | 7 days | 7 days | 7 days | |
| Elevated Slabs | 12 days | 7 days | 7 days | 7 days | |

C. When, in the opinion of the Engineer, conditions of the work or weather justify, forms may be required to remain in place for longer periods of time.

D. An accurate record shall be maintained by the Contractor of the dates of concrete placings and the exact location thereof and the dates of removal of forms. These records shall be available for inspection at all times at the site, and two copies shall be furnished the Engineer upon completion of the concrete work.

3.09 RESHORING

A. When reshoring is permitted or required the operations shall be planned in advance and subjected to approval by the Engineer.

B. Reshores shall be placed after stripping operations are complete but in no case later than the end of the working day on which stripping occurs.

C. Reshoring for the purpose of early form removal shall be performed so that at no time will large areas of new construction be required to support their own weight. While reshoring is under way, no construction or live loads shall be permitted on the new construction. Reshores shall be tightened to carry their required loads but they shall not be overtightened

so that the new construction is overstressed. Reshores shall remain in place until the concrete has reached its specified 28-day strength, unless otherwise specified.

D. For floors supporting shores under newly placed concrete, the original supporting shores shall remain in place or reshores shall be placed. The shoring or reshoring system shall have a capacity sufficient to resist the anticipated loads and in all cases shall have a capacity equal to at least one-half of the capacity of the shoring system above. Reshores shall be located directly under a reshore position above unless other locations are permitted.

E. In multi-story buildings, reshoring shall extend over a sufficient number of stories to distribute the weight of newly placed concrete, forms, and construction live loads so the design superimposed loads of the floors supporting shores are not exceeded.

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SECTION 03200

REINFORCING STEEL

PART 1 -- GENERAL

1.01 THE REQUIREMENTS

A. Provide all concrete reinforcing including all cutting, bending, fastening and any special work necessary to hold the reinforcing steel in place and protect it from injury and corrosion in accordance with the requirements of this section.

B. Provide deformed reinforcing bars to be grouted into reinforced concrete masonry walls.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 03100 - Concrete Formwork

B. Section 03250 - Concrete Accessories

C. Section 03300 - Cast-in-Place Concrete

1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.

1. South Carolina Building Code 2015.

2. CRSI - Concrete Reinforcing Institute Manual of Standard Practice

3. ACI SP66 - ACI Detailing Manual

4. ACI 315 - Details and Detailing of Concrete Reinforcing

5. ACI 318 - Building Code Requirements for Structural Concrete

6. ICC-ES AC193 Acceptance Criteria for Expansion and Screw Anchors (Concrete)

7. WRI - Manual of Standard Practice for Welded Wire Fabric

8. ASTM A 615 - Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcing

9. ASTM A 1064 - Standard Specification for Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete

1.04 SUBMITTALS

A. Submit the following in accordance with Section 01300, Submittals.

1. Detailed placing and shop fabricating drawings, prepared in accordance with ACI 315 and ACI Detailing Manual - (SP66), shall be furnished for all concrete reinforcing. These drawings shall be made to such a scale as to clearly show joint locations, openings, and the arrangement, spacing and splicing of the bars.

2. Mill test certificates - 3 copies of each.

3. Description of the reinforcing steel manufacturer's marking pattern.

4. Requests to relocate any bars that cause interferences or that cause placing tolerances to be violated.

5. Proposed supports for each type of reinforcing.

6. Request to use splices not shown on the Drawings.

7. Request to use mechanical couplers along with manufacturer's literature on mechanical couplers with instructions for installation, and certified test reports on the couplers' capacity.

8. Request and procedure to field bend or straighten partially embedded reinforcing.

9. International Code Council–Evaluation Services Report (ICC-ES ESR) for dowel adhesives.

10. Certification that all installers of dowel adhesive are certified as Adhesive Anchor Installers in accordance with the ACI-CRSI Anchor Installer Certification Program.

1.05 QUALITY ASSURANCE

A. If requested by the Engineer, the Contractor shall provide samples from each load of reinforcing steel delivered in a quantity adequate for testing. Costs of initial tests will be paid by the Owner. Costs of additional tests due to material failing initial tests shall be paid by the Contractor.

B. Provide a list of names of all installers who are trained by the Manufacturer's Field Representative on this jobsite prior to installation of products. Record must include the installer name, date of training, products included in the training and trainer name and contact information.

C. Provide a copy of the current ACI/CRSI "Adhesive Anchor Installer" certification cards for all installers who will be installing adhesive anchors in the horizontal to vertically overhead orientation.

D. Inspections of the adhesive dowel system may be made by the Engineer or other representatives of the Owner in accordance with the requirements of the ESR published by

the manufacturer. Provide adequate time and access for inspections of products and anchor holes prior to injection, installation, and proof testing.

## PART 2 -- PRODUCTS

### 2.01 REINFORCING STEEL

A. Bar reinforcing shall conform to the requirements of ASTM A 615 for Grade 60 Billet Steel reinforcing. All reinforcing steel shall be from domestic mills and shall have the manufacturer's mill marking rolled into the bar which shall indicate the producer, size, type and grade. All reinforcing bars shall be deformed bars. Smooth reinforcing bars shall not be used unless specifically called for on Drawings.

B. Welded wire fabric reinforcing shall conform to the requirements of ASTM A 1064 and the details shown on the Drawings.

C. A certified copy of the mill test on each load of reinforcing steel delivered showing physical and chemical analysis shall be provided, prior to shipment. The Engineer reserves the right to require the Contractor to obtain separate test results from an independent testing laboratory in the event of any questionable steel. When such tests are necessary because of failure to comply with this Specification, such as improper identification, the cost of such tests shall be borne by the Contractor.

D. Field welding of reinforcing steel will not be allowed.

E. Use of coiled reinforcing steel will not be allowed.

### 2.02 ACCESSORIES

A. Accessories shall include all necessary chairs, slab bolsters, concrete blocks, tie wires, dips, supports, spacers and other devices to position reinforcing during concrete placement.

B. Concrete blocks (dobies), used to support and position bottom reinforcing steel, shall have the same or higher compressive strength as specified for the concrete in which it is located.

### 2.03 MECHANICAL COUPLERS

A. Mechanical couplers shall develop a tensile strength which exceeds 100 percent of the ultimate tensile strength and 125 percent of the yield strength of the reinforcing bars being spliced. The reinforcing steel and coupler used shall be compatible for obtaining the required strength of the connection.

B. Where the type of coupler used is composed of more than one component, all components required for a complete splice shall be supplied.

C. Hot forged sleeve type couplers shall not be used. Acceptable mechanical couplers are Dayton Superior Dowel Bar Splicer System by Dayton Superior, Dayton, Ohio, or approved equal. Mechanical couplers shall only be used where shown on the Drawings or where specifically approved by the Engineer.

2.04 DOWEL ADHESIVE SYSTEM

A. Where shown on the Drawings, reinforcing bars anchored into hardened concrete with a dowel adhesive system shall use a two-component adhesive mix which shall be injected with a static mixing nozzle following manufacturer's instructions.

B. All holes shall be drilled in accordance with the manufacturer's instructions except that core drilled holes shall not be permitted unless specifically allowed by the Engineer. Cored holes, if allowed by the manufacturer and approved by the Engineer, shall be roughened in accordance with manufacturer's requirements.

C. Thoroughly clean drill holes of all debris, drill dust, and water in accordance with manufacturer's instructions prior to installation of adhesive and reinforcing bar.

D. Degree of hole dampness shall be in strict accordance with manufacturer recommendations. Installation conditions shall be either dry or water-saturated. Water filled or submerged holes shall not be permitted unless specifically approved by the Engineer.

E. Injection of adhesive into the hole shall be performed in a manner to minimize the formation of air pockets in accordance with the manufacturer's instructions.

F. Embedment Depth:

1. The embedment depth of the bar shall be as shown on the Drawings.

2. Where the embedment depth is not shown on the Drawings, the embedment depth shall be determined to provide the minimum allowable bond strength equal to the tensile strength of the rebar according to the manufacturer's ICC-ES ESR.

3. The embedment depth shall be determined using the actual concrete compressive strength, a cracked concrete state, maximum long term temperature of 110 degrees F, and maximum short term temperature of 140 degrees F. In no case shall the embedment depth be less than the minimum, or more than the maximum, embedment depths stated in the manufacturer's ICC-ES ESR.

G. Engineer's approval is required for use of this system in locations other than those shown on the Drawings.

H. The adhesive system shall be IBC compliant for use in both cracked and uncracked concrete in all Seismic Design Categories and shall be "Epcon C6+ Adhesive Anchoring System" as manufactured by ITW Redhead, " HIT-HY 200 Adhesive Anchoring System" as manufactured by Hilti, Inc. "SET-XP Epoxy Adhesive Anchors" as manufactured by Simpson Strong-Tie Co. or "Pure 110+ Epoxy Adhesive Anchor System" by DeWalt. Fast-set epoxy formulations shall not be acceptable. No or equal products will be considered, unless pre-qualified and approved.

I. All individuals installing dowel adhesive system shall be certified as an Adhesive Anchor Installer in accordance with the ACI-CRSI Anchor Installation Certification Program.

PART 3 – EXECUTION

3.01 TEMPERATURE REINFORCING

A. Unless otherwise shown on the Drawings or in the absence of the concrete reinforcing being shown, the minimum cross sectional area of horizontal and vertical concrete reinforcing in walls shall be 0.0033 times the gross concrete area and the minimum cross sectional area of reinforcing perpendicular to the principal reinforcing in slabs shall be 0.0020 times the gross concrete area. Temperature reinforcing shall not be spaced further apart than five times the slab or wall thickness, nor more than 18 inches.

3.02 FABRICATION

A. Reinforcing steel shall be accurately formed to the dimensions and shapes shown on the Drawings and the fabricating details shall be prepared in accordance with ACI 315 and ACI 318, except as modified by the Drawings.

B. The Contractor shall fabricate reinforcing bars for structures in accordance with the bending diagrams, placing lists and placing Drawings.

C. No fabrication shall commence until approval of Shop Drawings has been obtained. All reinforcing bars shall be shop fabricated unless approved to be bent in the field. Reinforcing bars shall not be straightened or rebent in a manner that will injure the material. Heating of bars will not be permitted.

D. Welded wire fabric with longitudinal wire of W9.5 size or smaller shall be either furnished in flat sheets or in rolls with a core diameter of not less than 10 inches. Welded wire fabric with longitudinal wires larger than W9.5 size shall be furnished in flat sheets only.

3.03 DELIVERY, STORAGE AND HANDLING

A. All reinforcing shall be neatly bundled and tagged for placement when delivered to the job site. Bundles shall be properly identified for coordination with mill test reports.

B. Reinforcing steel shall be stored above ground on platforms or other supports and shall be protected from the weather at all times by suitable covering. It shall be stored in an orderly manner and plainly marked to facilitate identification.

C. Reinforcing steel shall at all times be protected from conditions conducive to corrosion until concrete is placed around it.

D. The surfaces of all reinforcing steel and other metalwork to be in contact with concrete shall be thoroughly cleaned of all dirt, grease, loose scale and rust, grout, mortar and other foreign substances immediately before the concrete is placed. Where there is delay in depositing concrete, reinforcing shall be reinspected and if necessary recleaned.

3.04 PLACING

A. Reinforcing steel shall be accurately positioned as shown on the Drawings and shall be supported and wired together to prevent displacement, using annealed iron wire ties or

suitable clips at intersections. All reinforcing steel shall be supported by concrete, plastic supports, spacers or metal hangers which are strong and rigid enough to prevent any displacement of the reinforcing steel. Where concrete is to be placed on the ground, supporting concrete blocks (or dobies) shall be used in sufficient numbers to support the reinforcing bars without settlement. In no case shall concrete block supports be continuous.

B. The portions of all accessories in contact with the formwork shall be made of plastic or steel coated with a 1/8 inch minimum thickness of plastic which extends at least 1/2 inch from the concrete surface. Plastic shall be gray in color.

C. Tie wires shall be bent away from the forms in order to provide the specified concrete coverage.

D. Reinforcing bars additional to those shown on the Drawings, which may be found necessary or desirable by the Contractor for the purpose of securing reinforcing in position, shall be provided by the Contractor at no additional cost to the Owner.

E. Reinforcing placing, spacing, and protection tolerances shall be within the limits specified in ACI 318 except where in conflict with the Building Code, unless otherwise specified.

F. Reinforcing bars may be moved within one bar diameter as necessary to avoid interference with other concrete reinforcing, conduits, or embedded items. If bars are moved more than one bar diameter, or enough to exceed placing tolerances, the resulting arrangement of bars shall be as acceptable to the Engineer.

G. Welded wire fabric shall be supported on slab bolsters spaced not less than 30 inches on centers, extending continuously across the entire width of the reinforcing mat and supporting the reinforcing mat in the plane shown on the Drawings.

H. Reinforcing shall not be straightened or rebent unless specifically shown on the drawings. Bars with kinks or bends not shown on the Drawings shall not be used. Coiled reinforcement shall not be used.

I. Dowel Adhesive System shall be installed in strict conformance with the manufacturer's recommendations and as required in Article 2.04 above. A representative of the manufacturer must be on site prior to adhesive dowel installation to provide instruction on proper installation procedures for all adhesive dowel installers. Testing of adhesive dowels shall be as indicated below. If the dowels have a hook at the end to be embedded in subsequent work, an approved mechanical coupler shall be provided at a convenient distance from the face of existing concrete to facilitate adhesive dowel testing while maintaining required hook embedment in subsequent work.

J. All adhesive dowel installations in the horizontal or overhead orientation shall be conducted by a certified Adhesive Anchor Installer as certified by ACI/CSRI per ACI 318-11 9.2.2. Current AAI Certificated must be submitted to the Engineer of Record for approval prior to commencement of any adhesive anchor installations.

K. Adhesive Dowel Testing

1. At all locations where adhesive dowels are shown on the Drawings, at least 10

percent of all adhesive dowels installed shall be tested to the value indicated on the Drawings, with a minimum of one tested dowel per group. If no test value is indicated on the Drawings but the installed dowel is under direct tension, the Contractor shall notify the Engineer to verify the required test value.

2. Contractor shall submit a plan and schedule indicating locations of dowels to be tested, load test values and proposed dowel testing procedure (including a diagram of the testing equipment proposed for use) prior to conducting any testing. The testing equipment shall have a minimum of three support points and shall be of sufficient size to locate the edge of supports no closer than two times the anchor embedment depth from the center of the anchor.

3. Where Contract Documents indicate adhesive dowel design is the Contractor's responsibility, the Contractor shall submit a plan and schedule indicating locations of dowels to be tested and load test values, sealed by a Professional Engineer currently registered in the State of South Carolina. The Contractor shall also submit documentation indicating the Contractor's testing procedures have been reviewed and the proposed procedures are acceptable.

4. Adhesive Dowel shall have no visible indications of displacement or damage during or after the proof test. Concrete cracking in the vicinity of the dowel after loading shall be considered a failure. Dowels exhibiting damage shall be removed and replaced. If more than 5 percent of tested dowels fail, then 100 percent of dowels shall be proof tested.

5. Proof testing of adhesive dowels shall be performed by an independent testing laboratory hired directly by the Contractor. The Contractor shall be responsible for costs of all testing, including additional testing required due to previously failed tests.

3.05 SPLICING

A. Reinforcing bar splices shall only be used at locations shown on the Drawings. When it is necessary to splice reinforcing at points other than where shown, the splice shall be as acceptable to the Engineer.

B. The length of lap for reinforcing bars, unless otherwise shown on the Drawings shall be in accordance with ACI 318 for a class B splice.

C. Laps of welded wire fabric shall be in accordance with ACI 318. Adjoining sheets shall be securely tied together with No. 14 tie wire, one tie for each 2 running feet. Wires shall be staggered and tied in such a manner that they cannot slip.

D. Mechanical splices shall be used only where shown on the drawings or when approved by the Engineer.

E. Couplers which are located at a joint face shall be a type which can be set either flush or recessed from the face as shown on the Drawings. The couplers shall be sealed during concrete placement to completely eliminate concrete or cement paste from entering. After the concrete is placed, couplers intended for future connections shall be plugged and sealed to prevent any contact with water or other corrosive materials. Threaded couplers shall be plugged with plastic plugs which have an O-ring seal.

3.06 INSPECTION

A. The Contractor shall advise the Engineer of his intentions to place concrete and shall allow him adequate time to inspect all reinforcing steel before concrete is placed.

B. The Contractor shall advise the Engineer of his intentions to place grout in masonry walls and shall allow him adequate time to inspect all reinforcing steel before grout is placed.

3.07 CUTTING OF EMBEDDED REBAR

A. The Contractor shall not cut embedded rebar cast into structural concrete without prior approval.

- END OF SECTION -

SECTION 03250

CONCRETE ACCESSORIES

## PART 1 -- GENERAL

### 1.01 THE REQUIREMENT

A. Furnish all materials, labor and equipment required to provide all concrete accessories including waterstops, expansion joint material, joint sealants, expansion joint seals, contraction joint inserts, and epoxy bonding agent.

### 1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 03100 - Concrete Formwork

B. Section 03290 - Joints in Concrete

C. Section 03300 - Cast-in-Place Concrete

D. Section 07900 - Joint Fillers, Sealants, and Caulking

### 1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.

| | | |
|---|---|---|
| 1. | ASTM C881 | Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete |
| 2. | ASTM D412 | Standard Tests for Rubber Properties in Tension |
| 3. | ASTM D 624 | Standard Test method for Rubber Property - Tear Resistance |
| 4. | ASTM D 638 | Standard Test Method for Tensile Properties of Plastics |
| 5. | ASTM D1751 | Standard Specifications for Preformed Expansion Joint fillers for Concrete Paving and Structural Construction (nonextruding and resilient bituminous types) |
| 6. | ASTM D 1752 | Standard Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction |
| 7. | ASTM D 1171 | Standard Test Method for Ozone Resistance at 500 pphm |
| 8. | ASTM D 471 | Standard Test Method for Rubber Properties |

1.04 SUBMITTALS

A. Submit the following in accordance with Section 01300, Submittals.

1. Manufacturer's literature on all products specified herein including material certifications.

2. Proposed system for supporting PVC waterstops in position during concrete placement

3. Samples of products if requested by the Engineer.

PART 2 -- PRODUCTS

2.01 POLYVINYL CHLORIDE (PVC) WATERSTOPS

A. PVC waterstops for construction joints shall be flat ribbed type, 6 inches wide with a minimum thickness at any point of 3/8 inches.

B. Waterstops for expansion joints shall be ribbed with a center bulb. They shall be 9 inches wide with a minimum thickness at any point of 3/8 inch unless shown or specified otherwise. The center bulb shall have a minimum outside diameter of 1 inch and a minimum inside diameter of 1/2 inch.

C. The waterstops shall be manufactured from virgin polyvinyl chloride plastic compound and shall not contain any scrap or reclaimed material or pigment whatsoever. The properties of the polyvinyl chloride compound used, as well as the physical properties of the waterstops, shall exceed the requirements of the U.S. Army Corps. of Engineers' Specification CRD-C572. The waterstop material shall have an off-white, milky color.

D. The required minimum physical characteristics for this material are:

1. Tensile strength - 1,750 psi (ASTM D-638).

2. Ultimate elongation - not less than 280% (ASTM D-638).

E. No reclaimed PVC shall be used for the manufacturing of the waterstops. The Contractor shall furnish certification that the proposed waterstops meet the above requirements.

F. PVC waterstops shall be as manufactured by BoMetals, Inc., DuraJoint Concrete Accessories, or Sika Greenstreak.

G. All waterstop intersections, both vertical and horizontal, shall be made from factory fabricated corners and transitions. Only straight butt joint splices shall be made in field.

2.02 RETROFIT WATERSTOPS

A. Retrofit waterstops shall be used where specifically shown on Drawings for sealing joints between existing concrete construction and new construction.

B. Retrofit waterstops shall be PVC waterstops fabricated from material as described in Section 2.01 of this Specification.

C. Retrofit waterstop shall be attached to existing concrete surface as shown on Drawings.

D. Use of split waterstop in lieu of specially fabricated retrofit waterstop will not be acceptable.

E. Retrofit Waterstop manufacturer must provide a complete system including all Waterstop, stainless steel anchoring hardware, and epoxy for installation.

F. For construction joints, retrofit waterstop shall be style number 609 by Sika Greenstreak, RF-638 by BoMetals, Inc., Type 18 kit by DuraJoint Concrete Accessories, or approved equal. For expansion joints, retrofit waterstop shall be style number 667 by Sika Greenstreak, RF-912 by BoMetals, Inc., Type 18-9 kit by DuraJoint Concrete Accessories, or approved equal.

2.03 HYPALON RUBBER WATERSTOPS

A. Hypalon rubber waterstops shall be Sikadur Combiflex by Sika Corporation or approved equal. Minimum width of waterstop material shall be twelve (12) inches unless shown otherwise on Contract Drawings.

2.04 EXPANDING RUBBER WATERSTOP

A. Expanding rubber shall be designed to expand under hydrostatic conditions. Waterstops shall be Adeka Ultra Seal MC-2010MN by Adeka Ultra Seal/OCM, Inc., or Hydrotite CJ-1020-2K by Sika Greenstreak, for concrete thickness greater than nine inches. For thicknesses less than nine inches, Adeka Ultra Seal KBA-1510FF or Hydrotite CJ-1020-2K shall be used.

B. Waterstop shall be a chemically modified natural rubber product with a hydrophilic agent.

C. Waterstop has a stainless steel mesh or coextrusion of non-hydrophilic rubber to direct expansion in the thickness direction and restrict the expansion in the longitudinal direction.

2.05 WATERSTOP ADHESIVE

A. Adhesive between waterstops and existing concrete shall be Neoprene Adhesive 77-198 by JGF Adhesives, Sikadur 31 Hi-Mod Gel by Sika Corporation, DP-605 NS Urethane Adhesive by 3M Adhesive Systems.

B. Hydrophilic, non-bentonite water swelling elastic sealant shall be used to bond expanding rubber waterstops to rough surfaces. Hydrophilic elastic sealant shall be P-201 by Adeka Ultra Seal/OCM, Inc., Leakmaster LV-1 by Sika Greenstreak, or approved equal.

2.06 JOINT SEALANTS

A. Joint sealants shall comply with Section 07900, Joint Fillers, Sealants, and Caulking.

2.07 EXPANSION JOINT MATERIAL

A. Preformed expansion joint material shall be non-extruding, and shall be of the following types:

1. Type I - Sponge rubber, conforming to ASTM D1752, Type I.

2. Type II - Cork, conforming to ASTM D1752, Type II.

3. Type III - Self-expanding cork, conforming to ASTM D1752, Type III.

4. Type IV - Bituminous fiber, conforming to ASTM Designation D1751.

2.08 EXPANSION JOINT SEAL

A. Expansion Joint Seal System shall consist of a preformed neoprene profile, installed using the same dimensions as the joint gap, bonded with a two-component epoxy adhesive and pressurized during the adhesive cure time.

B. The expansion joint system shall be Hydrozo/Jeene Structural Sealing joint system by Hydrozo/Jeene, Inc.

2.09 CONTRACTION JOINT INSERTS

A. Contraction joint inserts shall be Zip-Cap by Greenstreak Plastic Products, Zip-Joint by BoMetals, Inc. control joint formers.

2.10 EPOXY BONDING AGENT

A. Epoxy bonding agent shall conform to ASTM C881 and shall be Sikadur 32 Hi-Mod, Sika Corporation, Lyndhurst, N.J.; Euco #452 Epoxy System, Euclid Chemical Company, Cleveland, OH, MasterInject 1500 by BASF Master Builder Solutions (BASF).

2.11 EPOXY RESIN BINDER

A. Epoxy resin binder shall conform to the requirements of ASTM C-881, Type III, Grade 3, Class B and C for epoxy resin binder and shall be Sikadur 23, Low-Mod-Gel, manufactured by the Sika Corporation, Lyndhurst, N.J., Flexocrete Gel manufactured by DuraJoint Concrete Accessories or Euco #352 Gel, Euclid Chemical Company, MasterEmaco ADH 327 or 327 RS by BASF Master Builder Solutions.

PART 3 -- EXECUTION

3.01 PVC AND CHEMICAL RESISTANT WATERSTOPS

A. PVC and chemical resistant waterstops shall be provided in all construction and expansion joints in water bearing structures and at other such locations as required by the Drawings.

B. Waterstops shall be carefully positioned so that they are embedded to an equal depth in concrete on both sides of the joint. They shall be kept free from oil, grease, mortar or other foreign matter. To ensure proper placement, all waterstops shall be secured in correct

position at 12" on center along the length of the waterstop on each side, prior to placing concrete. Such method of support shall be submitted to the Engineer for review and approval. Grommets or small pre-punched holes as close to the edges as possible will be acceptable for securing waterstops.

C. Splices in PVC waterstops and chemical resistant waterstops shall be made with a thermostatically controlled heating element. Only straight butt joint splices will be allowed in the field. Factory fabricated corners and transitions shall be used at all intersections. Splices shall be made in strict accordance with the manufacturer's recommended instructions and procedures. At least three satisfactory sample splices shall be made on the site. The Engineer may require tests on these splices by an approved laboratory. The splices shall exhibit not less than 80 percent of the strength of the unspliced material.

D. All splices in waterstops will be subject to rigid review for misalignment, bubbles, inadequate bond, porosity, cracks, offsets, discoloration, charring, and other defects which would reduce the potential resistance of the material to water pressure at any point. All defective joints shall be replaced with material which will pass said review and all faulty material shall be removed from the site and disposed of by the Contractor at no additional cost to the Owner.

E. Retrofit waterstops shall be installed as shown on Contract Drawings using approved waterstop adhesive and Type 316 stainless steel batten bars and expansion anchors.

F. Waterstop installation and splicing defects which are unacceptable include, but are not limited to the following:

1. Tensile strength not less than 80 percent of parent material.

2. Overlapped (not spliced) Waterstop.

3. Misalignment of Waterstop geometry at any point greater than 1/16 inch.

4. Visible porosity or charred or burnt material in weld area.

5. Visible signs of splice separation when splice (24 hours or greater) is bent by hand at sharp angle.

3.02 HYPALON RUBBER AND EXPANDING RUBBER WATERSTOPS

A. Waterstops shall be installed only where shown on the Drawings.

B. Waterstops shall be installed in strict accordance with manufacturer's recommendations.

3.03 WATERSTOP ADHESIVE

A. Adhesive shall be applied to both contact surfaces in strict accordance with manufacturer's recommendations.

B. Adhesive shall be used where waterstops are attached to existing concrete surfaces.

3.04 INSTALLATION OF EXPANSION JOINT MATERIAL AND SEALANTS

A. Type I, II, or III shall be used in all expansion joints in structures and concrete pavements unless specifically shown otherwise on the Drawings. Type IV shall be used in sidewalk and curbing and other locations specifically shown on the Drawings.

B. All expansion joints exposed in the finish work, exterior and interior, shall be sealed with the specified joint sealant. Expansion joint material and sealants shall be installed in accordance with manufacturer's recommended procedures and as shown on the Drawings.

C. Expansion joint material that will be exposed after removal of forms shall be cut and trimmed to ensure a neat appearance and shall completely fill the joint except for the space required for the sealant. The material shall be held securely in place and no concrete shall be allowed to enter the joint or the space for the sealant and destroy the proper functions of the joint.

D. A bond breaker shall be used between expansion joint material and sealant. The joint shall be thoroughly clean and free from dirt and debris before the primer and the sealant are applied. Where the finished joint will be visible, masking of the adjoining surfaces shall be carried out to avoid their discoloration. The sealant shall be neatly tooled into place and its finished surfaces shall present a clean and even appearance.

E. Type 1 joint sealant shall be used in all expansion and contraction joints in concrete, except where Type 7 or Type 8 is required as stated below, and wherever else specified or shown on the Drawings. It shall be furnished in pour grade or gun grade depending on installation requirements. Primers shall be used as required by the manufacturer. The sealant shall be furnished in colors as directed by the Engineer.

F. Type 8 joint sealant shall be used in all concrete pavements and floors subject to heavy traffic and wherever else specified or shown on the Drawings.

G. Type 7 joint sealant shall be used for all joints in chlorine contact tanks and wherever specified or shown on the Drawings.

3.05 EXPANSION JOINT SEAL

A. The expansion joint seal system shall be installed as shown on the Drawings in strict accordance with the manufacturer's recommendations.

3.06 CONTRACTION JOINT INSERTS

A. For contraction joints in slabs, inserts shall be floated in fresh concrete during finishing.

B. For contraction joints in walls, inserts shall be secured in place prior to casting wall.

C. Inserts shall be installed true to line at the locations of all contraction joints as shown on the Drawings.

D. Inserts shall extend into concrete sufficient depth as indicated on the Drawings or specified in Section 03290, Joints in Concrete.

E. Inserts shall not be removed from concrete until concrete has cured sufficiently to prevent chipping or spalling of joint edges due to inadequate concrete strength.

3.07 EPOXY BONDING AGENT

A. The Contractor shall use an epoxy bonding agent for bonding fresh concrete to existing concrete as shown on the Drawings.

B. Bonding surface shall be clean, sound and free of all dust, laitance, grease, form release agents, curing compounds, and any other foreign particles.

C. Application of bonding agent shall be in strict accordance with manufacturer's recommendations.

D. Fresh concrete shall not be placed against existing concrete if epoxy bonding agent has lost its tackiness.

3.08 EPOXY RESIN BINDER

A. Epoxy resin binder shall be used to seal all existing rebar cut and burned off during demolition operations. Exposed rebar shall be burned back 1/2-inch minimum into existing concrete and the resulting void filled with epoxy resin binder.

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SECTION 03290

JOINTS IN CONCRETE

PART 1 -- GENERAL

1.01 THE REQUIREMENTS

A. Provide all materials, labor and equipment required for the construction of all joints in concrete specified herein and shown on the Drawings.

B. Types of joints in concrete shall be as follows:

1. Construction Joints - Joints between adjacent concrete placements continuously connected with reinforcement.

2. Expansion Joints - Joints in concrete which allow thermal expansion and contraction of concrete. Reinforcement terminates within concrete on each side of joint.

3. Contraction Joints - Joints formed in concrete to provide a weakened plane in concrete section to control formation of shrinkage cracks.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 03100 - Concrete Formwork

B. Section 03250 - Concrete Accessories

C. Section 03300 - Cast-in-Place Concrete

D. Section 07900 - Joint Fillers, Sealants and Caulking

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.

1. ACI 301 - Specifications for Structural Concrete for Buildings

2. ACI 318 - Building Code Requirements for Structural Concrete

3. ACI 350 – Code Requirements for Environmental Engineering Concrete Structures

4. ACI 224.3 – Joints in Concrete Construction

1.04 SUBMITTALS

A. Submit the following in accordance with Section 01300, Submittals.

1. Layout drawings showing location and type of all joints to be placed in each structure.

2. Details of proposed joints in each structure.

## PART 2 -- MATERIALS

### 2.01 MATERIALS

A. All materials required for joint construction shall comply with Section 03250 - Concrete Accessories, and Section 07900 - Joint Fillers, Sealants and Caulking.

## PART 3 -- EXECUTION

### 3.01 CONSTRUCTION JOINTS

A. Construction joints shall be as shown on the Drawings. Otherwise, Contractor shall submit description of the joint and its location to Engineer for approval.

B. Unless noted otherwise on the Drawings, construction joints shall be located near the middle of the spans of slabs, beams, and girders unless a beam intersects a girder at this point. In this case, the joints in the girders shall be offset a distance equal to twice the width of the beam. Joints in walls and columns shall be at the underside of floors, slabs, beams, or girders and the top of footings or floor slabs unless noted otherwise on Drawings. Beams, girders, brackets, column capitals, haunches, and drop panels shall be placed at the same time as slabs. Joints shall be perpendicular to the main reinforcement.

C. Maximum distance between horizontal joints in slabs and vertical joints in walls shall be 45'-0". For exposed walls with fluid or earth on the opposite side, the spacing between vertical and horizontal joints shall be a maximum of 25’-0”.

D. All corners shall be part of a continuous placement, and should a construction joint be required, the joint shall not be located closer than five feet from a corner.

E. All reinforcing steel and welded wire fabric shall be continued across construction joints. Keys and inclined dowels shall be provided as shown on the Drawings or as directed by the Engineer. Longitudinal keys shall be provided in all joints in walls and between walls and slabs or footings, except as specifically noted otherwise on the Drawings. Size of keys shall be as shown on the Drawings.

F. All joints in water bearing structures shall have a waterstop. All joints below grade in walls or slabs which enclose an accessible area shall have a waterstop.

### 3.02 EXPANSION JOINTS

A. Size and location of expansion joints shall be as shown on the Drawings.

B. All expansion joints in water-bearing structures shall have a center-bulb type waterstop. All expansion joints below grade in walls or slabs which enclose an accessible area shall have a center-bulb type waterstop. Waterstop shall be as shown on Drawings and specified in Section 03250, Concrete Accessories.

3.03 CONTRACTION JOINTS

A. Location of contraction joints shall be as shown on the Drawings.

B. Contraction joints shall be formed with contraction joint inserts as specified in Section 03250, Concrete Accessories.

D. Unless noted otherwise on Drawings, depth of contraction joints shall be 1-1/2 inches in reinforced concrete and 1/3 of concrete thickness in unreinforced concrete.

3.04 JOINT PREPARATION

A. No concrete shall be allowed to enter the joint or the space for the sealant and destroy the proper functions of the joint.

B. The surface of the concrete at all joints shall be thoroughly cleaned and all laitance removed by wire brushing, air or light sand blasting.

C. The joint shall be thoroughly clean and free from dirt and debris before the primer and the sealant are applied. Where the finished joint will be visible, masking of the adjoining surfaces shall be carried out to avoid their discoloration. The sealant shall be neatly tooled into place and its finished surface shall present a clean and even appearance.

D. All joints shall be sealed as shown on the Drawings and specified in Section 03250, Concrete Accessories.

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SECTION 03300

CAST-IN-PLACE CONCRETE

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Provide all labor, equipment, materials and services necessary for the manufacture, transportation and placement of all plain and reinforced concrete work, as shown on the Drawings or as ordered by the Engineer.

B. The requirements in this section shall apply to the following types of concrete:

1. Class A1 Concrete: Normal weight structural concrete to be used in all structures qualifying as environmental concrete structures that are designed in accordance with ACI 350 including pump stations, tanks, basins, process structures, and any structures containing fluid or process chemicals or other materials used in treatment process.

2. Class A2 Concrete: Normal weight structural concrete in all structures other than structures qualifying as environmental concrete structures as described above, and for all sidewalks and pavement.

3. Class B Concrete: Normal weight structural concrete used for duct bank encasements, catch basins, fence and guard post embedment, concrete fill, and other areas where specifically noted on Contract Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 03100 - Concrete Formwork

B. Section 03200 - Reinforcing Steel

C. Section 03250 - Concrete Accessories

D. Section 03290 - Joints in Concrete

E. Section 03350 - Concrete Finishes

F. Section 03370 - Concrete Curing

G. Section 03600 - Grout

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Without limiting the generality of the Specifications, all work herein shall conform to or exceed the applicable requirements of the following documents. All referenced

specifications, codes, and standards refer to the most current issue available at the time of Bid.

1. International Building Code 2015

| | | |
|---|---|---|
| 2. | ACI 214 | Guide to Evaluation of Strength Test Results of Concrete |
| 3. | ACI 301 | Specifications for Structural Concrete |
| 4. | ACI 304 | Guide for Measuring, Mixing, Transporting, and Placing Concrete |
| 5. | ACI 305 | Guide to Hot Weather Concreting |
| 6. | ACI 306 | Guide to Cold Weather Concreting |
| 7. | ACI 309 | Guide for Consolidation of Concrete |
| 8. | ACI 318 | Building Code Requirements for Structural Concrete and Commentary |
| 9. | ACI 350 | Code Requirements for Environmental Engineering Concrete Structures |
| 10. | ASTM C 31 | Standard Practice for Making and Curing Concrete Test Specimens in the Field |
| 11. | ASTM C 33 | Standard Specification for Concrete Aggregates |
| 12. | ASTM C 39 | Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens |
| 13. | ASTM C42 | Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete |
| 14. | ASTM C 88 | Standard Test Method for Soundness of Aggregates by use of Sodium Sulfate or Magnesium Sulfate |
| 15. | ASTM C 94 | Standard Specification for Ready-Mixed Concrete |
| 16. | ASTM C 114 | Standard Test Method for Chemical Analysis of Hydraulic Cement |
| 17. | ASTM C 136 | Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates |
| 18. | ASTM C 138 | Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete |
| 19. | ASTM C 143 | Standard Test Method for Slump of Hydraulic Cement Concrete |
| 20. | ASTM C 150 | Standard Specification for Portland Cement |

21. ASTM C 172 Standard Practice for Sampling Freshly Mixed Concrete

22. ASTM C 192 Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory

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

24. ASTM C 260 Standard Specification for Air-Entraining Admixtures for Concrete

25. ASTM C 295 Standard Guide for Petrographic Examination of Aggregates for Concrete

26. ASTM C 457 Standard Test Method for Microscopical Determination of the Air-Void System in Hardened Concrete

27. ASTM C 494 Standard Specification for Chemical Admixtures for Concrete

28. ASTM C 595 Standard Specification for Blended Hydraulic Cements

29. ASTM C 618 Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete

30. ASTM C 989 Standard Specification for Slag Cement for Use in Concrete and Mortars

31. ASTM C 1077 Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation

32. ASTM C 1260 Test Method for Potential Alkali Reactivity of Aggregates (Mortar Bar Method)

33. ASTM C 1567 Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)

34. ASTM C 1602 Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete

35. ASTM C 1778 Reducing the Risk of Deleterious Alkali – Aggregate Reaction in Concrete

1.04 SUBMITTALS

A. Submit the following in accordance with Section 01300, Submittals.

1. Sources of all materials and certifications of compliance with specifications for all materials.

2. Certified current (less than 1 year old) chemical analysis of the Portland Cement or Blended Cement to be used.
3. Certified current (less than 1 year old) chemical analysis of fly ash or slag cement to be used.

4. Aggregate test results showing compliance with required standards, i.e., sieve analysis, potential reactivity, aggregate soundness tests, petrographic analysis, mortar bar expansion testing, etc.

5. Manufacturer's data on all admixtures stating compliance with required standards.

6. Concrete mix design for each class of concrete specified herein.

7. Field experience records and/or trial mix data for the proposed concrete mixes for each class of concrete specified herein.

1.05 QUALITY ASSURANCE

A. Tests on materials used in the production of concrete shall be required as specified in PART 2 -- PRODUCTS. These tests shall be performed by an independent testing laboratory approved by the Engineer at no additional cost to the Owner.

B. Trial concrete mixes shall be tested when required in accordance with Article 3.01 at no additional cost to the Owner.

C. Field quality control tests, as specified in Article 3.08, unless otherwise stated, will be performed by a materials testing consultant. However, the Contractor shall be charged for the cost of any additional tests and investigation on work performed which does not meet the Specifications. Any individual who samples and tests concrete to determine if the concrete is being produced in accordance with this Specification shall be certified as a Concrete Field Testing Technician, Grade I, in accordance with ACI CP-2. Testing laboratory shall conform to requirements of ASTM C-1077.

## PART 2 -- PRODUCTS

2.01 HYDRAULIC CEMENT

A. Portland Cement

1. Portland Cement shall be Type II conforming to ASTM C 150. Type I cement may be used provided either fly ash or slag cement is also included in the mix in accordance with Articles 2.02 or 2.03 respectively.

2. When potentially reactive aggregates as defined in Article 2.05 are to be used in concrete mix, cement shall meet the following requirements:

a. For concrete mixed with only Portland Cement, the total alkalies in the cement (calculated as the percentage of $NA_2O$ plus 0.658 times the percentage of $K_2O$) shall not exceed 0.40%.

b. For concrete mixed with Portland Cement and an appropriate amount of fly ash (Article 2.02) or slag cement (Article 2.03) the total alkalies in the Portland Cement (calculated as the percentage of $NA_2O$ plus 0.658 times the percentage of $K_2O$) shall not exceed 0.85%.

3. When non-reactive aggregates as defined in Article 2.05 are used in concrete mix, total alkalies in the cement shall not exceed 1.0%.

4. The proposed Portland Cement shall not contain more than 8% tricalcium aluminate and more than 12% tetracalcium aluminoferrite.

B. Blended Cement

1. Blended cements shall be Type IP (Portland Fly Ash Cement) or Type IS (Portland Slag Cement) conforming to ASTM C 595.

2. Type IP cement shall be an interground blend of Portland Cement and fly ash in which the fly ash constituent is between 15% and 25% of the weight of the total blend.

3. Type IS cement shall be an interground blend of Portland Cement and slag cement in which the slag constituent is between 35% and 50% of the weight of the total blend.

4. Fly ash and slag cement used in the production of blended cements shall meet the requirements of Articles 2.02 and 2.03, respectively.

5. When reactive aggregates as defined in Article 2.05 are used in concrete mix, the total alkalies in the Portland Cement (calculated as the percentage of $Na_2O$ plus 0.658 times the percentage of $K_2O$) shall not exceed 0.85%. The percentage of fly ash or slag cement shall be set to meet provisions of Article 2.05.G.2.

C. Different types of cement shall not be mixed nor shall they be used alternately except when authorized in writing by the Engineer. Different brands of cement or the same brand from different mills may be used alternately. A resubmittal will be required if different cements are proposed during the Project.

D. Cement shall be stored in a suitable weather-tight building so as to prevent deterioration or contamination. Cement which has become caked, partially hydrated, or otherwise damaged will be rejected.

2.02 FLY ASH

A. Fly ash shall meet the requirements of ASTM C 618 for Class F, except that the loss on ignition shall not exceed 4%. Fly ash shall also meet the optional physical requirements for uniformity as shown in Table 3 of ASTM C 618.

B. For fly ash to be used in the production of type IP cement, the Pozzolan Activity Index shall be greater than 75% as specified in Table 3 of ASTM C 595.

C. Where reactive aggregates as defined in Article 2.05 are used in concrete mix, the fly ash constituent shall be between 15% and 25% of the total weight of the combined Portland Cement and fly ash. The percentage of fly ash shall be set to meet the mean mortar bar expansion requirements in provisions of Article 2.05.G.2.

D. For Type A1 concrete as required for use in environmental concrete structures, i.e. process structures or fluid containing structures, inclusion of fly ash or slag cement in the concrete mix, is mandatory.

E. Additional fly ash shall not be included in concrete mixed with Type IS or IP cement.

2.03 SLAG CEMENT

A. Slag cement shall meet the requirements of ASTM C 989 including tests for effectiveness of slag in preventing excessive expansion due to alkali-aggregate reactivity as described in Appendix X-3 of ASTM C 989.

B. Where reactive aggregates as defined in Article 2.05 are used in concrete mix, the slag cement constituent shall be between 35% and 40% of the total weight of the combined Portland Cement and slag. The percentage of slag cement shall be set to meet the mean mortar bar expansion requirements in provisions of Article 2.05.F.2.

C. For Type A1 concrete as required for use in environmental concrete structures, i.e. process structures or fluid containing structures, inclusion of fly ash or slag cement in the concrete mix, is mandatory.

D. Additional slag cement shall not be included in concrete mixed with type IS or IP cement.

2.04 WATER

A. Water used for mixing concrete shall be clear, potable and free from deleterious substances such as objectionable quantities of silty organic matter, alkali, salts and other impurities.

B. Water shall not contain more than 100 PPM chloride.

C. Water shall not contain more than 500 PPM dissolved solids.

D. Water shall have a pH in the range of 4.5 to 8.5.

E. Water shall meet requirements of ASTM C 1602.

2.05 AGGREGATES

A. All aggregates used in normal weight concrete shall conform to ASTM C 33.

B. Fine Aggregate (Sand) in the various concrete mixes shall consist of natural or manufactured siliceous sand, clean and free from deleterious substances, and graded within the limits of ASTM C 33.

C. Coarse aggregates shall consist of hard, clean, durable gravel, crushed gravel or crushed rock. Coarse aggregate shall be size #57 or #67 as graded within the limits given in ASTM C 33 unless otherwise specified.

D. Aggregates shall be tested for gradation by sieve analysis tests in conformance with ASTM C 136.

E. Aggregates shall be tested for soundness in accordance with ASTM C 88. The loss resulting after five cycles shall not exceed 10 percent for fine or coarse aggregate when using either magnesium sulfate or sodium sulfate.

F. All aggregates shall be evaluated in accordance with ASTM C 1778 to determine potential reactivity. All aggregates shall be considered reactive unless they meet the requirements below for non-reactive aggregates. Aggregates with a lithology essentially similar to sources in the same region found to be reactive in service shall be considered reactive regardless of the results of the tests above.

1. Non-reactive aggregates shall meet the following requirements:

   A petrographic analysis in accordance with ASTM C295 shall be performed to identify the constituents of the fine and coarse aggregate. Non-reactive aggregates shall meet the following limitations:

   (a) Optically strained, microfractured, or microcrystalline quartz, 5.0%, maximum.

   (b) Chert or chalcedony, 3.0%, maximum.

   (c) Tridymite or cristobalite, 1.0%, maximum.

   (d) Opal, 0.5%, maximum.

   e) Natural volcanic glass in volcanic rocks, 3.0%, maximum.

2. Concrete mixed with reactive aggregates shall meet the following requirements:

   (a) If aggregates are deemed potentially reactive as per ASTM C-1778 and fly ash or slag cement is included in proposed concrete mix design, proposed concrete mix including proposed aggregates shall be evaluated by ASTM C-1567. Mean mortar bar expansions at 16 days shall be less than 0.08%. Tests shall be made using exact proportion of all materials proposed for use on the job in design mix submitted.

   (b) If aggregates are deemed potentially reactive as per ASTM C-1778 and a straight cement mix without fly ash or slag cement is proposed for concrete mix design, aggregates shall be evaluated by ASTM C-1260. Mean mortar bar expansions at 16 days shall be less than 0.08%.

G. Contractor shall submit a new trial mix to the Engineer for approval whenever a different aggregate or gradation is proposed.

2.06 STRUCTURAL MACRO FIBERS

A. Structural macro fibers shall meet requirements of ASTM C 1116 with a minimum length of 2 inches, an aspect ratio between 50 and 90, and a minimum toughness rating R10, 50=60 (approximate) in accordance with ASTM C 1609. Fibers shall be used only where specifically required on Contract Drawings or where specifically approved by Engineer.

B. Acceptable structural macro fibers are Tuf Strand SF by the Euclid Chemical Company, Strux 90/40 by W.R. Grace, or equal.

2.07 ADMIXTURES

A. Air entraining agent shall be added to all concrete unless noted otherwise. The agent shall consist of a neutralized vinsol resin solution or a purified hydrocarbon with a cement catalyst which will provide entrained air in the concrete in accordance with ASTM C 260. The admixture proposed shall be selected in advance so that adequate samples may be obtained and the required tests made. Air content of concrete, when placed, shall be within the ranges given in the concrete mix design.

B. The following admixtures are required or used for water reduction, slump increase, and/or adjustment of initial set. Admixtures permitted shall confirm to the requirements of ASTM C 494. Admixtures shall be non-toxic after 30 days and shall be compatible with and made by the same manufacturer as the air-entraining admixtures.

1. Water reducing admixture shall conform to ASTM C 494, Type A and shall contain no more than 0.05% chloride ions. Acceptable products are “Eucon Series” by the Euclid Chemical Company, “Master Pozzolith Series” by BASF, and “Plastocrete Series” by Sika Corporation.

2. High range water reducer shall be sulfonated polymer conforming to ASTM C 494, Type F or G. The high range water reducer shall be added to the concrete at either the batch plant or at the job site and may be used in conjunction with a water reducing admixture. The high range water reducer shall be accurately measured and pressure injected into the mixer as a single dose by an experienced technician. A standby system shall be provided and tested prior to each day’s operation of the job site system. Concrete shall be mixed at mixing speed for a minimum of 100 mixer revolutions after the addition of the high range water reducer. Acceptable products are “Eucon 37” or Plastol 5000 by the Euclid Chemical Company, “Master Rheobuild 1000 or Master Glenium Series” by BASF, and “Daracem 100 or Advaflow Series” by W.R. Grace.

3. A non-chloride, non-corrosive accelerating admixture may be used where specifically approved by the Engineer. The admixture shall conform to ASTM C 494, Type C or E, and shall not contain more chloride ions than are present in municipal drinking water. The admixture manufacturer must have long-term non-corrosive test data from an independent testing laboratory (of at least a year’s duration) using an acceptable accelerated corrosion test method such as that using electrical potential measures. Acceptable products are “Accelguard 80/90 or NCA” by the Euclid Chemical Company and “Daraset” by W.R. Grace.

4. A water reducing retarding admixture may be used where specifically approved by the Engineer. The admixture shall conform to ASTM C494, Type D and shall not contain more than 0.05% chloride ions. Acceptable products are “Eucon NR or Eucon Retarder 100” by the Euclid Chemical Company, “Pozzolith Retarder” by BASF, and “Plastiment” by Sika Corporation.

C. Admixtures containing calcium chloride, thiocyanate or more than 0.05 percent chloride ions are not permitted. The addition of admixtures to prevent freezing is not permitted.

D. The Contractor shall submit manufacturer's data including the chloride ion content of each admixture and certification from the admixture manufacturer that all admixtures utilized in the design mix are compatible with one another and properly proportioned prior to mix design review.

2.08 CONCRETE MIX DESIGN

A. The proportions of cement, aggregates, admixtures and water used in the concrete mixes shall be based on the results of field experience or preferably laboratory trial mixes in conformance with Section 5.3. "Proportioning on the Basis of Field Experience and/or Trial Mixtures" of ACI 318 and ACI 350. When trial mixes are used they shall also conform to Article 3.01 of this Section of the Specifications. If field experience records are used, concrete strength results shall be from concrete mixed with all of the ingredients proposed for use on job used in similar proportions to mix proposed for use on job. Contractor shall submit verification confirming this stipulation has been followed. Field experience records and/or trial mix data used as the basis for the proposed concrete mix design shall be submitted to the Engineer along with the proposed mix.

B. Structural concrete shall conform to the following requirements. Cementitious materials refer to the total combined weight of all cement, fly ash, and slag cement contained in the mix.

1. Compressive Strength (28-Day)

| | | |
|---|---|---|
| a. | Concrete Class A1 | 4,500 psi (minimum) |
| b. | Concrete Class A2 | 4,000 psi (minimum) |
| c. | Concrete Class B | 3,000 psi (minimum) |

2. Water/cementitious materials ratio, by weight

| | | Maximum | Minimum |
|---|---|---|---|
| a. | Concrete Class A1 | 0.42 | 0.39 |
| b. | Concrete Class A2 | 0.45 | 0.39 |
| c. | Concrete Class B | 0.50 | 0.39 |

3. Slump range — 4" nominal unless high range water reducing admixture is used.
8” max if high range water reducing admixture is used.

4. Air Content

a. Class A1, A2 6% ±1.5%

b. Class B 3% Max (non air-entrained)

PART 3 -- EXECUTION

3.01 TRIAL MIXES

A. When trial mixes are used to confirm the quality of a proposed concrete mix in accordance with Section 5.3, "Proportioning on the Basis of Field Experience and/or Trial Mixtures" of ACI 318 and ACI 350, an independent qualified testing laboratory designated and retained by the Contractor shall test a trial batch of each of the preliminary concrete mixes submitted by the Contractor. The trial batches shall be prepared using the aggregates, cement and admixtures proposed for the project. The trial batch materials shall be of a quantity such that the testing laboratory can obtain enough samples to satisfy requirements stated below. Tests on individual materials stated in PART 2 -- PRODUCTS should already be performed before any trial mix is done. The cost of laboratory trial batch tests for each specified concrete mix will be borne by the Contractor and the Contractor shall furnish and deliver the materials to the testing laboratory at no cost to the Owner.

B. The independent testing laboratory shall prepare a minimum of fifteen (15) standard test cylinders in accordance with ASTM C 31 in addition to conducting slump (ASTM C 143), air content (C 231) and unit weight (C 138) tests. Compressive strength test on the cylinders shall subsequently be performed by the same laboratory in accordance with ASTM C 39 as follows: Test 3 cylinders at age 7 days; test 3 cylinders at age 21 days; test 3 cylinders at age 28 days and test 3 cylinders at 56 days. The cylinders shall be carefully identified as "Trial Mix, Contract No. _____, Product _____." If the average 28-day compressive strength of the trial mix is less than that specified, or if any single cylinder falls below the required strength by more than 500 psi, the mix shall be corrected, another trial batch prepared, test cylinders taken, and new tests performed as before. Any such additional trial batch testing required shall be performed at no additional cost to the Owner. Adjustments to the mix shall be considered refinements to the mix design and shall not be the basis for extra compensation to the Contractor.

3.02 PRODUCTION OF CONCRETE

A. All concrete shall be machine mixed. Hand mixing of concrete will not be permitted. The Contractor may supply concrete from a ready mix plant or from a site mixed plant. In selecting the source for concrete production the Contractor shall carefully consider its capability for providing quality concrete at a rate commensurate with the requirements of the placements so that well bonded, homogenous concrete, free of cold joints, is assured.

B. Ready-Mixed Concrete

1. At the Contractor's option, ready-mixed concrete may be used meeting the requirements for materials, batching, mixing, transporting, and placing as specified herein and in accordance with ASTM C 94.

2. Truck mixers shall be equipped with electrically-actuated counters by which the number of revolutions of the drum or blades may be readily verified. The counter

shall be of the resettable, recording type, and shall be mounted in the driver's cab. The counters shall be actuated at the time of starting mixers at mixing speeds.

3. Each batch of concrete shall be mixed in a truck mixer for not less than 100 revolutions of the drum or blades at the rate of rotation designated by the manufacturer of equipment. Additional mixing, if any, shall be at the speed designated by the manufacturer of the equipment as agitating speed. All materials including mixing water shall be in the mixer drum before actuating the revolution counter for determining the number of revolutions of mixing.

4. Truck mixers and their operation shall be such that the concrete throughout the mixed batch, as discharged, is within acceptable limits of uniformity with respect to consistency, mix and grading. If slump tests taken at approximately the 1/4 and 3/4 points of the load during discharge give slumps differing by more than one inch when the specified slump is 3 inches or less, or if they differ by more than 2 inches when the specified slump is more than 3 inches, the mixer shall not be used on the work unless the causing condition is corrected and satisfactory performance is verified by additional slump tests. All mechanical details of the mixer, such as water measuring and discharge apparatus, condition of the blades, speed of rotation, general mechanical condition of the unit and clearance of the drum, shall be checked before a further attempt to use the unit will be permitted.

5. Ready-mixed concrete shall be delivered to the site for the work and discharge shall be completed before the drum has been revolved 300 revolutions and within the time requirements stated in Article 3.03 of this Section.

6. Each and every concrete delivery shall be accompanied by a delivery ticket containing at least the following information:

    a. Date and truck number
    b. Ticket number
    c. Mix designation of concrete
    d. Cubic yards of concrete
    e. Cement brand, type and weight in pounds
    f. Weight in pounds of fine aggregate (sand)
    g. Weight in pounds of coarse aggregate (stone)
    h. Air entraining agent, brand, and weight in pounds and ounces
    i. Other admixtures, brand, and weight in pounds and ounces
    j. Water, in gallons, stored in attached tank
    k. Water, in gallons, maximum that can be added without exceeding design water/cementitious materials ratio
    l. Water, in gallons, actually used (by truck driver)
    m. Time of loading
    n. Time of delivery to job (by truck driver)

7. Any truck delivering concrete to the job site, which is not accompanied by a delivery ticket showing the above information will be rejected and such truck shall immediately depart from the job site.

8. The use of non-agitating equipment for transporting ready-mixed concrete will not be permitted. Combination truck and trailer equipment for transporting ready-mixed

concrete will not be permitted. The quality and quantity of materials used in ready-mixed concrete and in batch aggregates shall be subject to continuous inspection at the batching plant by the Engineer.

C. Site Mixed Concrete

1. Scales for weighing concrete ingredients shall be accurate when in use within ±0.4 percent of their total capacities. Standard test weights shall be available to permit checking scale accuracy.

2. Operation of batching equipment shall be such that the concrete ingredients are consistently measured within the following tolerances:

| | | |
|---|---|---|
| a. | Cement, fly ash, or slag cement | ± 1 percent |
| b. | Water | ± 1 percent |
| c. | Aggregates | ± 2 percent |
| d. | Admixtures | ± 3 percent |

3. Each batch shall be so charged into the mixer that some water will enter in advance of the cement and aggregates. Water shall continue for a period which may extend to the end of the first 25 percent of the specified mixing time. Controls shall be provided to prevent batched ingredients from entering the mixer before the previous batch has been completely discharged.

4. The concrete shall be mixed in a batch mixer capable of thoroughly combining the aggregates, cement, and water into a uniform mass within the specified mixing time, and of discharging the concrete without harmful segregation. The mixer shall bear a manufacturer's rating plate indicating the rate capacity and the recommended revolutions per minute and shall be operated in accordance therewith.

5. Mixers with a rate capacity of 1 cu.yd. or larger shall conform to the requirements of the Plant Mixer Manufacturers' Division of the Concrete Plant Manufacturers' Bureau.

6. Except as provided below, batches of 1 cu. yd. or less shall be mixed for not less than 1 minute. The mixing time shall be increased 15 seconds for each cubic yard or fraction thereof of additional capacity.

7. Shorter mixing time may be permitted provided performance tests made in accordance with of ASTM C 94 indicate that the time is sufficient to produce uniform concrete.

8. Controls shall be provided to ensure that the batch cannot be discharged until the required mixing time has elapsed. At least three-quarters of the required mixing time shall take place after the last of the mixing water has been added.

9. The interior of the mixer shall be free of accumulations that will interfere with mixing action. Mixer blades shall be replaced when they have lost 10 percent of their original height.

10. Air-entraining admixtures and other chemical admixtures shall be charged into the mixer as solutions and shall be measured by means of an approved mechanical dispensing device. The liquid shall be considered a part of the mixing water. Admixtures that cannot be added in solution may be weighed or may be measured by volume if so recommended by the manufacturer.

11. If two or more admixtures are used in the concrete, they shall be added separately to avoid possible interaction that might interfere with the efficiency of either admixture or adversely affect the concrete.

12. Addition of retarding admixtures shall be completed within 1 minute after addition of water to the cement has been completed, or prior to the beginning of the last three-quarters of the required mixing, whichever occurs first. Retarding admixtures shall not be used unless approved by the Engineer.

13. Concrete shall be mixed only in quantities for immediate use and within the time and mixing requirements of ASTM C 94.

3.03 CONCRETE PLACEMENT

A. No concrete shall be placed prior to approval of the concrete mix design. Concrete placement shall conform to the recommendations of ACI 304.

B. Prior to concrete placement, all reinforcement shall be securely and properly fastened in its correct position. Formwork shall be clean, oiled and form ties at construction joints shall be retightened. All bucks, sleeves, castings, hangers, pipe, conduits, bolts, anchors, wire, and any other fixtures required to be embedded therein shall be in place. Forms for openings to be left in the concrete shall be in place and anchored by the Contractor. All loose debris in bottoms of forms or in keyways shall be removed and all debris, water, snow, ice and foreign matter shall be removed from the space to be occupied by the concrete. The Contractor shall notify the Engineer in advance of placement, allowing sufficient time for a concurrent inspection and for any corrective measures which are subsequently required.

C. On horizontal joints where concrete is to be placed on hardened concrete, flowing concrete containing a high range water reducing admixture or cement grout shall be placed with a slump not less than 8 inches for the initial placement at the base of the wall. Concrete or cement grout shall meet all strength and service requirements specified herein for applicable class of concrete. This concrete shall be worked well into the irregularities of the hard surface.

D. All concrete shall be placed during the daylight hours except with the consent of the Engineer. If special permission is obtained to carry on work during the night, adequate lighting must be provided.

E. When concrete arrives at the project with slump below that suitable for placing, as indicated by the Specifications, water may be added to bring the concrete within the specified slump range provided that the design water-cementitious materials ratio is not exceeded. The water shall be incorporated by additional mixing equal to at least half of the total mixing required. Water may be added only to full trucks. On-site tempering shall not relieve the Contractor from furnishing a concrete mix that meets all specified requirements.

F. Concrete shall be conveyed as rapidly as practicable to the point of deposit by methods which prevent the separation or loss of the ingredients. It shall be so deposited that rehandling will be unnecessary. Discharge of the concrete to its point of deposit shall be completed within 90 minutes after the addition of the cement to the aggregates. In hot weather, or under conditions contributing to quick stiffening of the concrete, the time between the introduction of the cement to the aggregates and discharge shall not exceed the requirements stated in Article 3.07 of this Section.

G. Where concrete is conveyed to position by chutes, a practically continuous flow in the chute shall be maintained. The angle and discharge arrangement of the chute shall be such as to prevent segregation of the concrete ingredients. The delivery end of the chute shall be as close as possible to the point of deposit and in no case shall the free pour from the delivery end of the chute exceed five feet, unless approved otherwise.

H. Special care must be exercised to prevent splashing of forms or reinforcement with concrete, and any such splashes or accumulations of hardened or partially hardened concrete on the forms or reinforcement above the general level of the concrete already in place must be removed before the work proceeds. Concrete shall be placed in all forms in such way as to prevent any segregation.

I. Placing of concrete shall be so regulated that the pressure caused by the wet concrete shall not exceed that used in the design of the forms.

J. All concrete for walls shall be placed through openings in the form spaced at frequent intervals or through tremies (heavy duct canvas, rubber, etc.), equipped with suitable hopper heads. Tremies shall be of variable lengths so the free fall shall not exceed five (5) feet and a sufficient number shall be placed in the form to ensure the concrete is kept level at all times.

K. When placing concrete which is to be exposed, sufficient illumination shall be provided in the interior of the forms so the concrete, at places of deposit, is visible from deck and runways.

L. Concrete shall be placed so as to thoroughly embed all reinforcement, inserts, and fixtures.

M. When forms are removed, surfaces shall be even and dense, free from aggregate pockets or honeycomb. To achieve this, concrete shall be consolidated using mechanical vibration, supplemented by forking and spading by hand in the corners and angle of forms and along form surfaces while the concrete is plastic under the vibratory action. Consolidation shall conform to ACI 309.

N. Mechanical vibration shall be applied directly to the concrete, unless otherwise approved by the Engineer. The bottom of vibrators used on floor slabs must not be permitted to ride the form supporting the slab. Vibration shall be applied at the point of deposit and in the area of freshly placed concrete by a vertical penetration of the vibrator. Vibrators shall not be used to move concrete laterally within the forms.

O. The intensity of vibration shall be sufficient to cause settlement of the concrete into place and to produce monolithic joining with the preceding layer. It shall be of sufficient duration to accomplish thorough compaction and complete embedment of reinforcement and fixtures with a vibrator transmitting not less than 7,500 impulses per minute. Since the duration of

vibration per square foot of surface is dependent on the frequency (impulses per minute), size of vibrator, and slump of concrete, the length of time must therefore be determined in the field. Vibration, however, shall not be continued in any one location to the extent that pools of grout are formed.

P. Care shall be taken to prevent cold joints when placing concrete in any portion of the work. The concrete placing rate shall be such as to ensure that each layer is placed while the previous layer is soft or plastic, so that the two layers can be made monolithic by penetration of the vibrators. Maximum thickness of concrete layers shall be 18 inches. The surface of the concrete shall be level whenever a run of concrete is stopped.

Q. To prevent featheredges, construction joints located at the tops of horizontal lifts near sloping exposed concrete surfaces shall be inclined near the exposed surface, so the angle between such inclined surface and the exposed concrete surface will be not less than 50°.

R. In placing unformed concrete on slopes, the concrete shall be placed ahead of a non-vibrated slip-form screed extending approximately 2-1/2 feet back from its leading edge. The method of placement shall provide a uniform finished surface with the deviation from the straight line less than 1/8 inch in any concrete placement. Concrete ahead of the slip-form screed shall be consolidated by internal vibrators so as to ensure complete filling under the slip-form. Prior to placement of concrete on sloped walls or slabs, the Contractor shall submit a plan specifically detailing methods and sequence of placements, proposed concrete screed equipment, location of construction joints and waterstops, and/or any proposed deviations from the aforementioned to the Engineer for review and approval.

S. Concrete shall not be placed during rains sufficiently heavy or prolonged to wash mortar from coarse aggregate on the forward slopes of the placement. Once placement of concrete has commenced in a block, placement shall not be interrupted by diverting the placing equipment to other uses.

3.04 PLACING FLOOR SLABS ON GRADE

A. The subgrade for slabs on ground shall be well drained and of adequate and uniform loadbearing nature. The in-place density of the subgrade soils shall be at least the minimum required by the specifications. No foundation, slab, or pavement concrete shall be placed until the depth and character of the foundation soils have been inspected and approved by the materials testing consultant.

B. The subgrade shall be free of frost before concrete placing begins. If the temperature inside a building where concrete is to be placed is below freezing it shall be raised and maintained above 50° long enough to remove all frost from the subgrade.

C. The subgrade shall be moist at the time of concreting. If necessary, it shall be dampened with water in advance of concreting, but there shall be no free water standing on the subgrade nor any muddy or soft spots when the concrete is placed.

D. Thirty-pound felt paper shall be provided between edges of slab-on-grade and vertical and horizontal concrete surfaces, unless otherwise indicated on the Drawings.

E. Contraction joints shall be provided in slabs-on-grade at locations indicated on the Drawings. Contraction joints shall be installed as per Section 03290 - Joints in Concrete.

F. Floor slabs shall be screeded level or pitched to drain as indicated on the Drawings. Finishes shall conform with requirements of Section 03350 - Concrete Finishes. Interior floor slabs shall be placed with non-air-entrained concrete (Class A3) if a steel troweled or hardened finish is required.

3.05 ORDER OF PLACING CONCRETE

A. In order to minimize the effects of shrinkage, the concrete shall be placed in units as bounded by construction joints shown on the Drawings and maximum lengths as indicated on Drawings. Where required on the Drawings and wherever else practical, the placing of such units shall be done in a strip pattern in accordance with ACI 302.1. A minimum of 72 hours shall pass prior to placing concrete directly adjacent to previously placed concrete.

3.06 CONCRETE WORK IN COLD WEATHER

A. Cold weather concreting procedures shall conform to the requirements of ACI 306.

B. The Engineer may prohibit the placing of concrete at any time when air temperature is 40°F. or lower. If concrete work is permitted, the concrete shall have a minimum temperature, as placed, of 55°F. for placements less than 12" thick, 50°F. for placements 12" to 36" thick, and 45°F. for placements greater than 36" thick. The temperature of the concrete as placed shall not exceed the aforementioned minimum values by more than 20°F, unless otherwise approved by the Engineer.

C. All aggregate and water shall be preheated. Precautions shall be taken to avoid the possibility of flash set when aggregate or water are heated to a temperature in excess of 100°F. in order to meet concrete temperature requirements. The addition of admixtures to the concrete to prevent freezing is not permitted. All reinforcement, forms, and concrete accessories with which the concrete is to come in contact shall be defrosted by an approved method. No concrete shall be placed on frozen ground.

3.07 CONCRETE WORK IN HOT WEATHER

A. Hot weather concreting procedures shall conform to the requirements of ACI 305.

B. When air temperatures exceed 85°F., or when extremely dry conditions exist even at lower temperatures, particularly if accompanied by high winds, the Contractor and his concrete supplier shall exercise special and precautionary measures in preparing, delivering, placing, finishing, curing and protecting the concrete mix. The Contractor shall consult with the Engineer regarding such measures prior to each day's placing operation and the Engineer reserves the right to modify the proposed measures consistent with the requirements of this Section of the Specifications. All necessary materials and equipment shall be on hand an in position prior to each placing operation.

C. Preparatory work at the job site shall include thorough wetting of all forms, reinforcing steel and, in the case of slab pours on ground or subgrade, spraying the ground surface on the preceding evening and again just prior to placing. No standing puddles of water shall be permitted in those areas which are to receive the concrete.

D. The temperature of the concrete mix when placed shall not exceed 90°F.

E. Temperature of mixing water and aggregates shall be carefully controlled and monitored at the supplier's plant, with haul distance to the job site being taken into account. Stockpiled aggregates shall, if necessary, be shaded from the sun and sprinkled intermittently with water. If ice is used in the mixing water for cooling purposes, it must be entirely melted prior to addition of the water to the dry mix.

F. Delivery schedules shall be carefully planned in advance so that concrete is placed as soon as practical after it is properly mixed. For hot weather concrete work (air temperature greater than 85°F), discharge of the concrete to its point of deposit shall be completed within 60 minutes from the time the concrete is batched.

G. The Contractor shall arrange for an ample work force to be on hand to accomplish transporting, vibrating, finishing, and covering of the fresh concrete as rapidly as possible.

3.08 QUALITY CONTROL

A. Field Testing of Concrete

1. The Contractor shall coordinate with the Engineer's project representative the on-site scheduling of the materials testing consultant personnel as required for concrete testing.

2. Concrete for testing shall be supplied by the Contractor at no additional cost to the Owner, and the Contractor shall provide assistance to the materials testing consultant in obtaining samples. The Contractor shall dispose of and clean up all excess material.

B. Consistency

1. The consistency of the concrete will be checked by the materials testing consultant by standard slump cone tests. The Contractor shall make any necessary adjustments in the mix as the Engineer and/or the materials testing consultant may direct and shall upon written order suspend all placing operations in the event the consistency does not meet the intent of the specifications. No payment shall be made for any delays, material or labor costs due to such eventualities.

2. Slump tests shall be made in accordance with ASTM C 143. Slump tests will be performed as deemed necessary by the materials testing consultant and each time compressive strength samples are taken.

3. Concrete with a specified nominal slump shall be placed having a slump within 1” (higher or lower) of the specified slump. Concrete with a specified maximum slump shall be placed having a slump less than the specified slump.

C. Unit Weight

1. Samples of freshly mixed concrete shall be tested for unit weight by the materials testing consultant in accordance with ASTM C 138.

2. Unit weight tests will be performed as deemed necessary by the Engineer and each time compressive strength samples are taken.

D. Air Content

1. Samples of freshly mixed concrete will be tested for entrained air content by the materials testing consultant in accordance with ASTM C 231.

2. Air content tests will be performed as deemed necessary by the materials testing consultant and each time compressive strength samples are taken.

3. In the event test results are outside the limits specified, additional testing shall occur. Admixture quantity adjustments shall be made immediately upon discovery of incorrect air entrainment.

E. Compressive Strength

1. Samples of freshly mixed concrete will be taken by the materials testing consultant and tested for compressive strength in accordance with ASTM C 172, C 31 and C 39, except as modified herein.

2. In general, one sampling shall be taken for each placement in excess of five (5) cubic yards, with a minimum of one (1) sampling for each day of concrete placement operations, or for each one hundred (100) cubic yards of concrete, or for each 5,000 square feet of surface area for slabs or walls, whichever is greater.

3. Each sampling shall consist of at least five (5) 6x12 cylinders or (8) 4x8 cylinders. Each cylinder shall be identified by a tag, which shall be hooked or wired to the side of the container. The materials testing consultant will fill out the required information on the tag, and the Contractor shall satisfy himself that such information shown is correct.

4. The Contractor shall be required to furnish labor to the Owner for assisting in preparing test cylinders for testing. The Contractor shall provide approved curing boxes for storage of cylinders on site. The insulated curing box shall be of sufficient size and strength to contain all the specimens made in any four consecutive working days and to protect the specimens from falling over, being jarred or otherwise disturbed during the period of initial curing. The box shall be erected, furnished and maintained by the Contractor. Such box shall be equipped to provide the moisture and to regulate the temperature necessary to maintain the proper curing conditions required by ASTM C 31. Such box shall be located in an area free from vibration such as pile driving and traffic of all kinds and such that all specimen are shielded from direct sunlight and/or radiant heating sources. No concrete requiring inspection shall be delivered to the site until such storage curing box has been provided. Specimens shall remain undisturbed in the curing box until ready for delivery to the testing laboratory but not less than sixteen hours.

5. The Contractor shall be responsible for maintaining the temperatures of the curing box during the initial curing of test specimens with the temperature preserved between 60°F and 80°F as measured by a maximum-minimum thermometer. The Contractor shall maintain a written record of curing box temperatures for each day

curing box contains test specimens. Temperature shall be recorded a minimum of three times a day with one recording at the start of the work day and one recording at the end of the work day.

6. When transported, the cylinders shall not be thrown, dropped, allowed to roll, or be damaged in any way.

7. Compression tests shall be performed in accordance with ASTM C 39. For 6x12 cylinders, two test cylinders will be tested at seven days and two at 28 days. For 4x8 cylinders, three test cylinders will be tested at seven days, three at 28 days. The remaining cylinders will be held to verify test results, if needed.

F. Evaluation and Acceptance of Concrete

1. Evaluation and acceptance of the compressive strength of concrete shall be according to the requirements of ACI 214, ACI 318, and ACI 350.

2. The strength level of concrete will be considered satisfactory if all of the following conditions are satisfied.

a. Every arithmetic average of any three consecutive strength tests equals or exceeds the minimum specified 28-day compressive strength for the mix (see Article 2.08).

b. No individual compressive strength test results falls below the minimum specified strength by more than 500 psi.

3. In the event any of the conditions listed above are not met, the mix proportions shall be corrected for the next concrete placing operation.

4. In the event that condition 2b is not met, additional tests in accordance with Article 3.08, paragraph H shall be performed.

5. When a ratio between 7-day and 28-day strengths has been established by these tests, the 7-day strengths shall subsequently be taken as a preliminary indication of the 28-day strengths. Should the 7-day test strength from any sampling be more than 10% below the established minimum strength, the Contractor shall:

a. Immediately provide additional periods of curing in the affected area from which the deficient test cylinders were taken.

b. Maintain or add temporary structural support as required.

c. Correct the mix for the next concrete placement operation, if required to remedy the situation.

6. All concrete which fails to meet the ACI requirements and these specifications is subject to removal and replacement at no additional cost to the Owner.

G. When non-compliant concrete is identified, test reports shall be sent immediately to the Engineer for review.

H. Additional Tests

1. When ordered by the Engineer, additional tests on in-place concrete shall be provided and paid for by the Contractor.

2. In the event the 28-day test cylinders fail to meet the minimum strength requirements as outlined in Article 3.08, paragraph F, the Contractor shall have concrete core specimens obtained and tested from the affected area immediately.

   a. Three cores shall be taken for each sample in which the strength requirements were not met.

   b. The drilled cores shall be obtained and tested in conformance with ASTM C 42. The tests shall be conducted by a materials testing consultant approved by the Engineer.

   c. The location from which each core is taken shall be approved by the Engineer. Each core specimen shall be located, when possible, so its axis is perpendicular to the concrete surface and not near formed joints or obvious edges of a unit of deposit.

   d. The core specimens shall be taken, if possible, so no reinforcing steel is within the confines of the core.

   e. The diameter of core specimens should be at least 3 times the maximum nominal size of the course aggregate used in the concrete, but must be at least 2-inches in diameter.

   f. The length of specimen, when capped, shall be at least twice the diameter of the specimen.

   g. The core specimens shall be taken to the laboratory and when transported, shall not be thrown, dropped, allowed to roll, or damaged in any way.

   h. Two (2) copies of test results shall be mailed directly to the Engineer. The concrete in question will be considered acceptable if the average compressive strength of a minimum of three test core specimens taken from a given area equal or exceed 85% of the specified 28-day strength and if the lowest core strength is greater than 75% of the specified 28-day strength.

3. In the event that concrete placed by the Contractor is suspected of not having proper air content, the Contractor shall engage a materials testing consultant approved by the Engineer, to obtain and test samples for air content in accordance with ASTM Specification C 457.

3.09 CARE AND REPAIR OF CONCRETE

A. The Contractor shall protect all concrete against injury or damage from excessive heat, lack of moisture, overstress, or any other cause until final acceptance by the Owner. Particular care shall be taken to prevent the drying of concrete and to avoid roughening or otherwise

damaging the surface. Care shall be exercised to avoid jarring forms or placing any strain on the ends of projecting reinforcing bars. Any concrete found to be damaged, or which may have been originally defective, or which becomes defective at any time prior to the final acceptance of the completed work, or which departs from the established line or grade, or which, for any other reason, does not conform to the requirements of the Contract Documents, shall be satisfactorily repaired or removed and replaced with acceptable concrete at no additional cost to the Owner.

B. Areas of honeycomb shall be chipped back to sound concrete and repaired as directed.

C. Concrete formwork blowouts or unacceptable deviations in tolerances for formed surfaces due to improperly constructed or misaligned formwork shall be repaired as directed. Bulging or protruding areas, which result from slipping or deflecting forms shall be ground flush or chipped out and redressed as directed.

D. Areas of concrete in which cracking, spalling, or other signs of deterioration develop prior to final acceptance shall be removed and replaced, or repaired as directed. This stipulation includes concrete that has experienced cracking due to drying or thermal shrinkage of the concrete. Structural cracks shall be repaired using an approved epoxy injection system. Non-structural cracks shall be repaired using an approved hydrophilic resin pressure injected grout system, unless other means of repair are deemed necessary and approved. All repair work shall be performed at no additional cost to the Owner.

E. Concrete which fails to meet the strength requirements as outlined in Article 3.08, paragraph F, will be analyzed as to its adequacy based upon loading conditions, resultant stresses and exposure conditions for the particular area of concrete in question. If the concrete in question is found unacceptable based upon this analysis, that portion of the structure shall be strengthened or replaced by the Contractor at no additional cost to the Owner. The method of strengthening or extent of replacement shall be as directed by the Engineer.

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SECTION 03350

CONCRETE FINISHES

## PART 1 -- GENERAL

### 1.01 THE REQUIREMENT

A. Furnish all materials, labor, and equipment required to provide finishes of all concrete surfaces specified herein and shown on the Drawings.

### 1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 03100 – Concrete Formwork

B. Section 03300 – Cast-in-Place Concrete

C. Section 03600 – Grout

### 1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.

1. ACI 301 – Specifications for Structural Concrete for Buildings

2. ACI 318 – Building Code Requirements for Structural Concrete

### 1.04 SUBMITTALS

A. Submit the following in accordance with Section 01300 – Submittals.

1. Manufacturer's literature on all products specified herein.

## PART 2 -- PRODUCTS

### 2.01 CONCRETE FLOOR SEALER

A. Floor sealer shall be Diamond Clear VOX or Super Diamond Clear VOX by the Euclid Chemical Company, MasterKure CC 300 SB by BASF Master Builder Solutions.

## PART 3 -- EXECUTION

### 3.01 FINISHES ON FORMED CONCRETE SURFACES

A. After removal of forms, the finishes described below shall be applied in accordance with Article 3.05 - Concrete Finish Schedule. Unless the finish schedule specifies otherwise, all surfaces shall receive at least a Type I finish. The Engineer shall be the sole judge of acceptability of all concrete finish work.

1. Type I - Rough: All fins, burrs, offsets, marks and all other projections left by the forms shall be removed. Projections, depressions, etc. below finished grade required to be removed will only be those greater than ¼-inch. All holes left by removal of ends of ties, and all other holes, depressions, bugholes, air/blow holes or voids shall be filled solid with cement grout after first being thoroughly wetted and then struck off flush. The only holes below grade to be filled will be tie holes and any other holes larger than ¼-inch in any dimension. Honeycombs shall be chipped back to solid concrete and repaired as directed by the Engineer. All holes shall be filled with tools, such as sponge floats and trowels, that will permit packing the hole solidly with cement grout. Cement grout shall consist of one part cement to three parts sand, epoxy bonding agent (for tie holes only) and the amount of mixing water shall be as little as consistent with the requirements of handling and placing. Color of cement grout shall match the adjacent wall surface.

2. Type II - Grout Cleaned: Where this finish is required, it shall be applied after completion of Type I finish. After the concrete has been predampened, a slurry consisting of one part cement (including an appropriate quantity of white cement in order to produce a color matching the surrounding concrete) and 1-1/2 parts sand passing the No. 16 sieve, by damp loose volume, shall be spread over the surface with clean burlap pads or sponge rubber floats. Mix proportions shall be submitted to the Engineer after a sample of the work is established and accepted. Any surplus shall be removed by scraping and then rubbing with clean burlap.

3.02 SLAB AND FLOOR FINISHES

A. The finishes described below shall be applied to floors, slabs, flow channels and top of walls in accordance with Article 3.05 - Concrete Finish Schedule. The Engineer shall be the sole judge of acceptability of all such finish work.

1. Type "A" - Screeded: This finish shall be obtained by placing screeds at frequent intervals and striking off to the surface elevation required.

2. Type "B" - Wood or Magnesium Floated: This finish shall be obtained after completion of a Type "A" finish by working a previously screeded surface with a wood or magnesium float or until the desired texture is reached. Floating shall begin when the water sheen has disappeared and when the concrete has sufficiently hardened so that a person's foot leaves only a slight imprint. If wet spots occur, water shall be removed with a squeegee. Care shall be taken to prevent the formation of laitance and excess water on the finished surface. All edges shall be edged with an 1/8-inch tool as directed by the Engineer. The finished surface shall be true, even, and free from blemishes and any other irregularities.

3. Type "E" - Broom or Belt: This finish shall provide the surface with a transverse scored texture by drawing a broom or burlap belt across the surface immediately after completion of a Type "B" finish. All edges shall be edged with an 1/8-inch tool as directed by the Engineer.

3.03 CONCRETE SEALERS

A. Concrete sealers shall be applied where specifically required on the Contract Drawings or specified herein.

B. Sealers shall be applied after installation of all equipment, piping, etc. and after completion of any other related construction activities. Application of sealers shall be in strict accordance with manufacturer's requirements.

C. Sealers shall be applied to all floor slabs not painted and not intended to be immersed.

D. Floor slabs subjected to vehicular traffic shall be sealed with the concrete liquid densifier and sealer.

E. All other floor slabs to receive sealer shall be sealed with concrete floor sealer.

3.04 FINISHES ON EQUIPMENT PADS

A. Formed surfaces of equipment pads shall receive a Type II finish.

B. Top surfaces of equipment pads which will later receive grout shall, before the concrete takes its final set, be made rough by removing the sand and cement that accumulates on the top to the extent that the aggregate will be exposed with irregular indentations in the surface up to 1/2 inch deep.

3.05 CONCRETE FINISH SCHEDULE

| Item | Type of Finish |
|---|---|
| Concrete surfaces indicated to receive textured coating (as noted on Drawings and in Section 09800, Special Coatings) | I |
| Inner face of walls of tanks, flow channels, wet wells, perimeter walls, and miscellaneous concrete structures: | |
| From 1 feet below water surface to bottom of wall | I |
| From top of wall to 1 feet below water surface | II |
| Exterior concrete walls below grade | I |
| Exterior exposed concrete walls, ceilings, beams, manholes, hand holes, miscellaneous structures and columns (including top of wall) to one foot below grade. All other exposed concrete surfaces not specified elsewhere | II |
| Floors of process equipment tanks or basins, wetwells, flow channels and slabs to receive roofing material or waterproof membranes | B |
| Exterior concrete sidewalks, steps, ramps, decks, slabs on grade and landings exposed to weather | E |

- END OF SECTION -

SECTION 03370

CONCRETE CURING

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Protect all freshly deposited concrete from premature drying and from the weather elements. The concrete shall be maintained with minimal moisture loss at a relatively constant temperature for a period of time necessary for the hydration of the cement and proper hardening of the concrete in accordance with the requirements specified herein.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 03100 – Concrete Formwork

B. Section 03300 – Cast-In-Place Concrete

C. Section 03350 – Concrete Finishes

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.

1. ACI 301 – Specifications for Structural Concrete for Buildings

2. ACI 304 – Guide for Measuring, Mixing, Transporting, and Placing Concrete

3. ACI 305 – Hot Weather Concreting

4. ACI 306 – Cold Weather Concreting

5. ACI 308 – Standard Practice for Curing Concrete

6. ASTM C171 – Standard Specifications for Sheet Materials for Curing Concrete

7. ASTM C309 – Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete

8. ASTM C1315 – Standard Specification for Liquid Membrane-Forming Compounds Having Special Properties for Curing and Sealing Concrete

1.04 SUBMITTALS

A. Submit the following in accordance with Section 01300, Submittals.

1. Proposed procedures for protection of concrete under wet weather placement conditions.

2. Proposed normal procedures for protection and curing of concrete.

3. Proposed special procedures for protection and curing of concrete under hot and cold weather conditions.

4. Proposed method of measuring concrete surface temperature changes.

5. Manufacturer's literature and material certification for proposed curing compounds.

## PART 2 -- PRODUCTS

### 2.01 LIQUID MEMBRANE-FORMING CURING COMPOUND

A. Clear curing and sealing compound shall be a clear styrene acrylate type complying with ASTM C 1315, Type 1, Class A with a minimum solids content of 30%. Moisture loss shall not be greater than 0.40 kg/$m^2$ when applied at 300 sq.ft./gal. Manufacturer's certification is required. Acceptable products are Super Diamond Clear VOX by the Euclid Chemical Company, MasteKure CC 300 SB by BASF Master Builder Solutions, and Cure & Seal 30 Plus by Symons Corporation.

B. Where specifically approved by Engineer, on slabs to receive subsequent applied finishes, compound shall conform to ASTM C 309. Acceptable products are "Kurez DR VOX" or "Kurez W VOX" by the Euclid Chemical Company. Install in strict accordance with manufacturer's requirements.

### 2.02 EVAPORATION REDUCER

A. Evaporation reducer shall be BASF, "MasterKure ER 50", or Euclid Chemical "Euco-Bar".

## PART 3 -- EXECUTION

### 3.01 PROTECTION AND CURING

A. All freshly placed concrete shall be protected from the elements, flowing water and from defacement of any nature during construction operations.

B. As soon as the concrete has been placed and horizontal top surfaces have received their required finish, provision shall be made for maintaining the concrete in a moist condition for at least a 5-day period thereafter except for high early strength concrete, for which the period shall be at least the first three days after placement. Horizontal surfaces shall be kept covered, and intermittent, localized drying will not be permitted.

C. Walls that will be exposed on one side with either fluid or earth backfill on the opposite side shall be continuously wet cured for a minimum of five days. Use of a curing compound will not be acceptable for applications of this type.

D. The Contractor shall use one of the following methods to ensure that the concrete remains in a moist condition for the minimum period stated above.

1. Ponding or continuous fogging or sprinkling.

2. Application of mats or fabric kept continuously wet.

3. Continuous application of steam (under 150°F).

4. Application of sheet materials conforming to ASTM C171.

5. If approved by the Engineer, application of a curing compound in accordance with Article 3.04.

E. The Contractor shall keep absorbent wood forms wet until they are removed. After form removal, the concrete shall be cured by one of the methods in paragraph D.

F. Any of the curing procedures used in Paragraph 3.01-D may be replaced by one of the other curing procedures listed in Paragraph 3.01-D after the concrete is one-day old. However, the concrete surface shall not be permitted to become dry at any time.

3.02 CURING CONCRETE UNDER COLD WEATHER CONDITIONS

A. Suitable means shall be provided for a minimum of 72 hours after placing concrete to maintain it at or above the minimum as placed temperatures specified in Section 03300, Cast-In-Place Concrete, for concrete work in cold weather. During the 72-hour period, the concrete surface shall not be exposed to air more than 20°F above the minimum as placed temperatures.

B. Stripping time for forms and supports shall be increased as necessary to allow for retardation in concrete strength caused by colder temperatures. This retardation is magnified when using concrete made with blended cements or containing fly ash or ground granulated blast furnace slag. Therefore, curing times and stripping times shall be further increased as necessary when using these types of concrete.

C. The methods of protecting the concrete shall be approved by the Engineer and shall be such as will prevent local drying. Equipment and materials approved for this purpose shall be on the site in sufficient quantity before the work begins. The Contractor shall assist the Engineer by providing holes in the forms and the concrete in which thermometers can be placed to determine the adequacy of heating and protection. All such thermometers shall be furnished by the Contractor in quantity and type which the Engineer directs.

D. Curing procedures during cold weather conditions shall conform to the requirements of ACI 306.

3.03 CURING CONCRETE UNDER HOT WEATHER CONDITIONS

A. When air temperatures exceed 85°F, the Contractor shall take extra care in placing and finishing techniques to avoid formation of cold joints and plastic shrinkage cracking. If ordered by the Engineer, temporary sun shades and/or windbreakers shall be erected to

guard against such developments, including generous use of wet burlap coverings and fog sprays to prevent drying out of the exposed concrete surfaces.

B. Immediately after screeding, horizontal surfaces shall receive an application of evaporation reducer. Apply in accordance with manufacturer's instructions. Final finish work shall begin as soon as the mix has stiffened sufficiently to support the workmen.

C. Curing and protection of the concrete shall begin immediately after completion of the finishing operation. Continuous moist-curing consisting of method 1 or 2 listed in paragraph 3.01D is mandatory for at least the first 24 hours. Method 2 may be used only if the finished surface is not marred or blemished during contact with the coverings.

D. At the end of the initial 24-hour period, curing and protection of the concrete shall continue for at least six (6) additional days using one of the methods listed in paragraph 3.01D.

E. Curing procedures during hot weather conditions shall conform to the requirements of ACI 305.

3.04 USE OF CURING COMPOUND

A. Curing compound shall be used only where specifically approved by the Engineer. Curing compound shall never be used for curing exposed walls with fluid or earth backfill on the opposite side. A continuous wet cure for a minimum of five days is required for these applications. Curing compound shall not be used on surfaces exposed to water in potable water storage tanks and treatment plants unless curing compound is certified in accordance with ANSI/NSF Standard 61.

B. When permitted, the curing compound shall maintain the concrete in a moist condition for the required time period, and the subsequent appearance of the concrete surface shall not be affected.

C. The compound shall be applied in accordance with the manufacturer's recommendations after water sheen has disappeared from the concrete surface and after finishing operations. Maximum coverage for the curing and sealing compound shall be 300 square feet per gallon for trowel finishes and 200 square feet per gallon for floated or broom surfaces. Maximum coverage for compounds placed where subsequent finishes will be applied shall be 200 square feet per gallon. For rough surfaces, apply in two directions at right angles to each other.

3.05 EARLY TERMINATION OF CURING

A. Moisture retention measures may be terminated earlier than the specified times only when at least one of the following conditions is met:

1. The strength of the concrete reaches 85 percent of the specified 28-day compressive strength in laboratory-cured cylinders representative of the concrete in place, and the temperature of the in-place concrete has been constantly maintained at 50 degrees Fahrenheit or higher.

2. The strength of concrete reaches the specified 28-day compressive strength as determined by accepted nondestructive methods or laboratory-cured cylinder test results.

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SECTION 03600

GROUT

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Furnish all materials, labor, and equipment required to provide all grout used in concrete work and as bearing surfaces for base plates, in accordance with the Contract Documents.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Requirements of related work are included in Division 1 and Division 2 of these Specifications.

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.

| | | |
|---|---|---|
| 1. | CRD-C 621 | Corps of Engineers Specification for Non-shrink Grout |
| 2. | ASTM C 109 | Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2 inch or 50 mm cube Specimens) |
| 3. | ASTM C 531 | Standard Test Method for Linear Shrinkage and Coefficient of Thermal Expansion of Chemical-Resistant Mortars, Grouts and Monolithic Surfacings |
| 4. | ASTM C 579 | Test Method for Compressive Strength of Chemical-Resistant Mortars and Monolithic Surfacings |
| 5. | ASTM C 827 | Standard Test Method for Early Volume Change of Cementitious Mixtures |
| 6. | ASTM C 144 | Standard Specification for Aggregate for Masonry Mortar |
| 7. | ASTM C 1107 | Standard Specification for Packaged Dry, Hydraulic Cement Grout (Nonshrink) |

1.04 SUBMITTALS

A. Submit the following in accordance with Section 01300 - Submittals.

1. Certified test results verifying the compressive strength and shrinkage and expansion requirements specified herein.

2. Manufacturer's literature containing instructions and recommendations on the mixing, handling, placement and appropriate uses for each type of grout used in the work.

1.05 QUALITY ASSURANCE

A. Field Tests

1. Compression test specimens will be taken during construction from the first placement of each type of grout and at intervals thereafter as selected by the Engineer to ensure continued compliance with these Specifications. The specimens will be made by the Engineer or its representative.

a. Compression tests and fabrication of specimens for cement grout and non-shrink grout will be performed as specified in ASTM C 109 at intervals during construction as selected by the Engineer. A set of three specimens will be made for testing at seven days, 28 days and any additional time period as appropriate.

b. Compression tests and fabrication of specimens for epoxy grout will be performed as specified in ASTM C 579, Method B, at intervals during construction as selected by the Engineer. A set of three specimens will be made for testing at seven days and any other time period as appropriate.

2. The cost of all laboratory tests on grout will be borne by the Owner, but the Contractor shall assist the Engineer in obtaining specimens for testing. The Contractor shall be charged for the cost of any additional tests and investigation on work performed which does not meet the specifications. The Contractor shall supply all materials necessary for fabricating the test specimens, at no additional cost to the Owner.

3. All grout, already placed, which fails to meet the requirements of these Specifications, is subject to removal and replacement at no additional cost to the Owner.

PART 2 -- PRODUCTS

2.01 MATERIALS

A. Cement Grout

1. Cement grout shall be composed of Portland Cement and sand in the proportion specified in the Contract Documents and the minimum amount of water necessary to obtain the desired consistency. If no proportion is indicated, cement grout shall consist of one part Portland Cement to three parts sand. Water amount shall be as required to achieve desired consistency without compromising strength requirements. White Portland Cement shall be mixed with the Portland Cement as required to match color of adjacent concrete.

2. The minimum compressive strength at 28 days shall be 4000 psi.

3. For beds thicker than 1-1/2 inch and/or where free passage of grout will not be obstructed by coarse aggregate, 1-1/2 parts of coarse aggregate having a top size of 3/8 inch should be added. This stipulation does not apply for grout being swept in by a mechanism. These applications shall use a plain cement grout without coarse aggregate regardless of bed thickness.

4. Sand shall conform to the requirements of ASTM C144.

B. Non-Shrink Grout

1. Non-shrink grout shall conform to CRD-C 621 and ASTM C 1107, Grade B or C when tested at a max. fluid consistency of 30 seconds per CDC 611/ASTM C939 at temperature extremes of 45°F and 90°F and an extended working time of 15 minutes. Grout shall have a min. 28-day strength of 7,000 psi. Non-shrink grout shall be, "Euco N-S" by the Euclid Chemical Company, "Sikagrout 212" by Sika Corporation, “Conspec 100 Non-Shrink Non-Metallic Grout” by Conspec, “Masterflow 555 Grout” by BASF Master Builder Solutions.

2.02 CURING MATERIALS

A. Curing materials shall be as specified in Section 03370, Concrete Curing for cement grout and as recommended by the manufacturer for prepackaged grouts.

PART 3 -- EXECUTION

3.01 GENERAL

A. The different types of grout shall be used for the applications stated below unless noted otherwise in the Contract Documents. Where grout is called for in the Contract Documents which does not fall under any of the applications stated below, non-shrink grout shall be used unless another type is specifically referenced.

1. Cement grout shall be used for grout toppings and for patching of fresh concrete.

2. Non-shrink grout shall be used for grouting beneath base plates of structural metal framing.

B. New concrete surfaces to receive cement grout shall be as specified in Section 03350, Concrete Finishes, and shall be cleaned of all dirt, grease and oil-like films. Existing concrete surfaces shall likewise be cleaned of all similar contamination and debris, including chipping or roughening the surface if a laitance or poor concrete is evident. The finish of the grout surface shall match that of the adjacent concrete. Curing and protection of cement grout shall be as specified in Section 03370, Concrete Curing.

C. All mixing, surface preparation, handling, placing, consolidation, and other means of execution for prepackaged grouts shall be done according to the instructions and recommendations of the manufacturer.

D. The Contractor, through the manufacturer of a non-shrink grout, shall provide on-site technical assistance upon request, at no additional cost to the Owner.

3.02 CONSISTENCY

A. The consistency of grouts shall be that necessary to completely fill the space to be grouted for the particular application. Dry pack consistency is such that the grout is plastic and moldable but will not flow.

3.03 MEASUREMENT OF INGREDIENTS

A. Measurements for cement grout shall be made accurately by volume using containers. Shovel measurement shall not be allowed.

B. Prepackaged grouts shall have ingredients measured by means recommended by the manufacturer.

3.04 GROUT INSTALLATION

A. Grout shall be placed quickly and continuously, shall completely fill the space to be grouted and be thoroughly compacted and free of air pockets. The grout may be poured in place, pressure grouted by gravity, or pumped. The use of pneumatic pressure or dry-packed grouting requires approval of the Engineer. For grouting beneath base plates, grout shall be poured from one side only and thence flow across to the open side to avoid air-entrapment.

- END OF SECTION -

SECTION 05010

METAL MATERIALS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Metal materials not otherwise specified shall conform to the requirements of this Section.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Materials for fasteners are included in Section 05050, Metal Fastening.

B. Requirements for specific products made from the materials specified herein are included in other sections of the Specifications. See the section for the specific item in question.

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. ASTM A36 Standard Specification for Structural Steel

B. ASTM A276 Standard Specification for Stainless and Heat-Resisting Steel Bars and Shapes

C. ASTM A307 Standard Specification for Carbon Steel Externally Threaded Standard Fasteners

D. ASTM A446 Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Structural (Physical) quality

E. ASTM A500 Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes

F. ASTM A501 Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing

G. ASTM A529 Standard Specification for Structural Steel with 42 000 psi (290 Mpa) Minimum Yield Point (1/2 in. (12.7 mm) Maximum Thickness)

H. ASTM A570 Standard Specification for Hot-Rolled Carbon Steel Sheet and Strip, Structural Quality

I. ASTM A992 Standard Specification for Structural Steel Shapes

J. ASTM A1085 Standard Specification for Cold-Formed Welded Carbon Steel Hollow Structural Sections (HSS)

K. ASTM B209 Standard Specification for Aluminum-Alloy Sheet and Plate

L. ASTM B221 Standard Specification for Aluminum-Alloy Extruded Bars, Rods, Wire, Shapes, and Tubes

M. ASTM F593 Standard Specification for Stainless Steel Fasteners

1.04 SUBMITTALS

A. Material certifications shall be submitted along with any shop drawings for metal products and fabrications required by other sections of the Specifications.

1.05 QUALITY ASSURANCE

A. Owner may engage the services of a testing agency to test any metal materials for conformance with the material requirements herein. If the material is found to be in conformance with Specifications the cost of testing will be borne by the Owner. If the material does not conform to the Specifications, the cost of testing shall be paid by the Contractor and all materials not in conformance as determined by the Engineer shall be replaced by the Contractor at no additional cost to the Owner. In lieu of replacing materials the Contractor may request further testing to determine conformance, but any such testing shall be paid for by the Contractor regardless of outcome of such testing.

PART 2 -- PRODUCTS

2.01 CARBON AND LOW ALLOY STEEL

A. Material types and ASTM designations shall be as listed below:

| | | |
|---|---|---|
| 1. | Steel W Shapes | A992 |
| 2. | Steel HP Shapes | A572 Grade 50 |
| 3. | Steel M, S, C, and MC shapes and Angles, Bars, and Plates | A36 |
| 4. | Rods | F 1554 Grade 36 |
| 5. | Pipe - Structural Use | A53 Grade B |
| 6. | Hollow Structural Sections | A500 Grade C or A1085 |

2.02 STAINLESS STEEL

A. All stainless steel fabrications exposed to underwater service shall be Type 316. All other stainless steel fabrications shall be Type 304, unless noted otherwise.

B. Material types and ASTM designations are listed below:

| | | |
|---|---|---|
| 1. | Plates and Sheets | ASTM A167 or A666 Grade A |

2. Fasteners (Bolts, etc.) ASTM F593

2.03 ALUMINUM

A. All aluminum shall be alloy 6061-T6, unless otherwise noted or specified herein.

B. All aluminum shall be provided with mill finish unless otherwise noted.

C. Where bolted connections are indicated, aluminum shall be fastened with stainless steel bolts.

2.04 DISSIMILAR METALS

A. Dielectric isolation shall be installed wherever dissimilar metals are connected according to the following table.

| | Zinc | Galvanized Steel | Aluminum | Cast Iron | Ductile Iron | Mild Steel/ Carbon Steel | Copper | Brass | Stainless Steel |
|---|---|---|---|---|---|---|---|---|---|
| Zinc | | | ● | ● | ● | ● | ● | ● | ● |
| Galvanized Steel | | | ● | ● | ● | ● | ● | ● | ● |
| Aluminum | ● | ● | | ● | ● | ● | ● | ● | ● |
| Cast Iron | ● | ● | ● | | | | ● | ● | ● |
| Ductile Iron | ● | ● | ● | | | | ● | ● | ● |
| Mild Steel/ Carbon Steel | ● | ● | ● | | | | ● | ● | ● |
| Copper | ● | ● | ● | ● | ● | ● | | | ● |
| Brass | ● | ● | ● | ● | ● | ● | | | ● |
| Stainless Steel | ● | ● | ● | ● | ● | ● | ● | ● | |

1. "●" signifies dielectric isolation is required between the two materials noted.
2. Consult Engineer for items not listed in table.

PART 3 -- EXECUTION

(NOT USED)

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SECTION 05035

GALVANIZING

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Where galvanizing is called for in the Contract Documents, the galvanizing shall be performed in accordance with the provisions of this Section unless otherwise noted.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Further requirements for galvanizing specific items may be included in other Sections of the Specifications. See section for the specific item in question.

1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.

1. International Building Code 2015.

2. ASTM A123 - Standard Specification for Zinc (Hot-Galvanized) Coatings on Products Fabricated from Rolled, Pressed, and Forged Steel Shapes, Plates, Bars, and Strip

3. ASTM A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

4. ASTM A653 - Standard Specification for Steel Sheet, Zinc Coated (Galvanized), or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

4. ASTM A924 - Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process

5. ASTM A780 - Standard Practice of Repair of Damaged Hot-Dip Galvanized Coatings

6. ASTM F2329 - Standard Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners

1.04 SUBMITTALS

A. Submit the following in accordance with Section 01300, Submittals.

1. Certification that the item(s) are galvanized in accordance with the applicable ASTM standards specified herein. This certification may be included as part of any material certification that may be required by other Sections of the Specifications.

PART 2 -- PRODUCTS

2.01 GALVANIC COATING

A. Material composition of the galvanic coating shall be in accordance with the applicable ASTM standards specified herein.

PART 3 -- EXECUTION

3.01 FABRICATED PRODUCTS

A. Products fabricated from rolled, pressed, and forged steel shapes, plates, bars, and strips, 1/8 inch thick and heavier which are to be galvanized shall be galvanized in accordance with ASTM A123. Products shall be fabricated into the largest unit which is practicable to galvanize before the galvanizing is done. Fabrication shall include all operations necessary to complete the unit such as shearing, cutting, punching, forming, drilling, milling, bending, and welding. Components of bolted or riveted assemblies shall be galvanized separately before assembly. When it is necessary to straighten any sections after galvanizing, such work shall be performed without damage to the zinc coating. The galvanizer shall be a member of American Galvanizers Association.

B. Components with partial surface finishes shall be commercial blast cleaned prior to pickling.

C. Sampling and testing of each lot shall be performed prior to shipment from the galvanizer's facility per ASTM A123.

3.02 HARDWARE

A. Iron and steel hardware which is to be galvanized shall be galvanized in accordance with ASTM A153 and ASTM F2329.

3.03 ASSEMBLED PRODUCTS

A. Assembled steel products which are to be galvanized shall be galvanized in accordance with ASTM A123. All edges of tightly contacting surfaces shall be completely sealed by welding before galvanizing.

B. Assemblies shall be provided with vent and drain holes as required by the fabricator. Vent and drain hole sizes and locations shall be included in the structural steel shop drawings required in Specification 05120 Structural Steel for approval. All vent and drain holes shall be plugged and finished to be flush with and blend in with the surrounding surface. Where water intrusion can occur, the plug shall be carefully melted into the surrounding zinc coating using an appropriate fluxing agent.

3.04 REPAIR OF GALVANIZING

A. Galvanized surfaces that are abraded or damaged at any time after the application of zinc coating shall be repaired by thoroughly wire brushing the damaged areas and removing all loose and cracked coating, after which the cleaned areas shall be painted with 2 coats of zinc rich paint meeting the requirements of Federal Specification DOD-P-21035A and shall be thoroughly mixed prior to application. Zinc rich paint shall not be tinted. The total thickness of the 2 coats shall not be less than 6 mils. In lieu of repairing by painting with zinc rich paint, other methods of repairing galvanized surfaces in accordance with ASTM A780 may be used provided the proposed method is acceptable to the Engineer.

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SECTION 05050

METAL FASTENING

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Furnish all materials, labor, and equipment required to provide all metal welds and fasteners not otherwise specified, in accordance with the Contract Documents.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 05010 - Metal Materials

B. Section 05035 - Galvanizing

C. Section 05061 – Stainless Steel

D. Section 05120 - Structural Steel

1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.

1. International Building Code 2015.

2. AC 193 Acceptance Criteria for Mechanical Anchors in Concrete Elements

3. AC 308 Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements

4. ACI 318 Building Code Requirements for Structural Concrete

5. ACI 355.2 Qualifications of Post-Installed Mechanical Anchors in Concrete

6. ACI 355.4 Qualifications of Post-Installed Adhesive Anchors in Concrete

7. ICC-ES AC193 Acceptance Criteria for Expansion and Screw Anchors (Concrete)

8. AISC 348 The 2009 RCSC Specification for Structural Joints

| | | |
|---|---|---|
| 9. | AISC | Code of Standard Practice |
| 10. | AWS D1.1 | Structural Welding Code - Steel |
| 11. | AWS D1.2 | Structural Welding Code - Aluminum |
| 12. | ASTM A572/A572M-94C | Standard Specification for High Strength Low-Alloy Columbium-Vanadium Structural Steel Grade 50 |
| 13. | ASTM A36 | Standard Specification for Carbon Structural Steel |
| 14. | ASTM A325 | Standard Specification for High-Strength Bolts for Structural Steel Joints |
| 15. | ASTM A490 | Standard Specification for Quenched and Tempered Alloy Steel Bolts for Structural Steel Joints |
| 16. | ASTM A563 | Standard Specifications for Carbon and Alloy Steel Nuts |
| 17. | ASTM D1785 | Standard Specification for Polyvinyl Chloride (PVC) Plastic Pipe |
| 18. | ASTM E488 | Standard Test Methods for Strength of Anchors in Concrete and Masonry Elements |
| 19. | ASTM F436 | Standard Specification for Hardened Steel Washers |
| 20. | ASTM F593 | Standard Specification for Stainless Steel Bolts; Hex Cap Screws, and Studs |
| 21. | ASTM F594 | Standard Specification for Stainless Steel Nuts |
| 22. | ASTM F1554 | Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength |

1.04 SUBMITTALS

A. Submit the following in accordance with Section 01300, Submittals.

1. Shop Drawings providing the fastener's manufacturer and type and certification of the fastener's material and capacity.

2. Anchor design calculations sealed by a Professional Engineer currently registered in the State of South Carolina.

3. A current ICC-ES Evaluation Service Report shall be submitted for all anchors that will be considered for use on this project.

4. Manufacturer’s installation instructions.

5. Copy of valid certification for each person who is to perform field welding.

6. Certified weld inspection reports when required.

7. Welding procedures.

8. Installer qualifications.

9. Certification of Installer Training.

10. Inspection Reports.

10. Results of Anchor Proof Testing.

1.05 QUALITY ASSURANCE

A. Fasteners not manufactured in the United States shall be tested and certification provided with respect to specified quality and strength standards. Certifications of origin shall be submitted for all U.S. fasteners supplied on the project.

B. Installer Qualifications: All concrete anchors shall be installed by an Installer with at least three years of experience performing similar installations. Concrete adhesive anchor installer shall be certified as an Adhesive Anchor Installer in accordance with ACI-CRSI Adhesive Anchor Installation Certification Program.

C. Installer Training: For concrete adhesive, expansion and screw anchors, conduct a thorough training with the manufacturer or the manufacturer's representative for the Installer on the project. Training shall consist of a review of the complete installation process to include but not be limited to the following:

1. Hole drilling procedure.

2. Hole preparation and cleaning technique.

3. Adhesive injection technique and dispenser training/maintenance.

4. Concrete adhesive anchor preparation and installation.

5. Proof loading/torquing.

6. Provide a list of names of all installers who are trained by the Manufacturer's Field Representative on this jobsite prior to installation of products. Record must include the installer name, date of training, products included in the training and trainer name and contact information

7. Provide a copy of the current ACI/CRSI "Adhesive Anchor Installer" certification cards for all installers who will be installing adhesive anchors in the horizontal to vertically overhead orientation.

D. All steel welding shall be performed by welders certified in accordance with AWS D1.1. All aluminum welding shall be performed by welders certified in accordance with AWS D1.2. All stainless steel welding shall be performed by welders certified in accordance with AWS D1.6. Certifications of field welders shall be submitted prior to performing any field welds.

E. Welds and high strength bolts used in connections of structural steel will be visually inspected in accordance with Article 3.04.

F. The Owner may engage an independent testing agency to perform testing of welded connections and to prepare test reports in accordance with AWS. Inadequate welds shall be corrected or redone and retested to the satisfaction of the Engineer and/or an acceptable independent testing laboratory, at no additional cost to the Owner.

G. Provide a welding procedure for each type and thickness of weld. For welds that are not prequalified, include a Performance Qualification Report. The welding procedure shall be given to each welder performing the weld. The welding procedure shall follow the format in Annex E of AWS D1.1 with relevant information presented.

H. Inspections of the adhesive dowel system shall be made by the Engineer or other representatives of the Owner in accordance with the requirements of the ESR published by the manufacturer. Provide adequate time and access for inspections of products and anchor holes prior to injections, installation, and proof testing. Special inspections for concrete adhesive anchors shall be conducted in accordance with the manufacturer's instructions and Specifications Section 01450. Downward installations require periodic inspection and horizontal and overhead installations require continuous inspection.

## PART 2 -- PRODUCTS

### 2.01 ANCHOR RODS (ANCHOR BOLTS)

A. Anchor rods shall conform to ASTM F1554 Grade 36 except where stainless steel or other approved anchor rods are shown on the Drawings. Anchor rods shall have hexagonal heads and shall be supplied with hexagonal nuts meeting the requirements of ASTM A563 Grade A.

B. Where anchor rods are used to anchor galvanized steel or are otherwise specified to be galvanized, anchor rods and nuts shall be hot-dip galvanized in accordance with ASTM F1554.

### 2.02 HIGH STRENGTH BOLTS

A. High strength bolts and associated nuts and washers shall be in accordance with ASTM A325 or ASTM A490. Bolts, nuts and washers shall meet the requirements of AISC 348 "The 2009 RCSC Specification for Structural Joints".

B. Where high strength bolts are used to connect galvanized steel or are otherwise specified to be galvanized, bolts, nuts, and washers shall be hot-dip galvanized in accordance with ASTM A325.

2.03 STAINLESS STEEL BOLTS

A. Stainless steel bolts shall conform to ASTM F-593. All underwater fasteners, fasteners in confined areas containing fluid, and fasteners in corrosive environments shall be Type 316 stainless steel unless noted otherwise. Fasteners for aluminum and stainless steel members not subject to the above conditions shall be Type 304 stainless steel unless otherwise noted.

B. Stainless steel bolts shall have hexagonal heads with a raised letter or symbol on the bolts indicating the manufacturer, and shall be supplied with hexagonal nuts meeting the requirements of ASTM F594. Nuts shall be of the same alloy as the bolts.

2.04 CONCRETE ANCHORS

A. General

1. Where concrete anchors are called for on the Drawings, one of the types listed below shall be used; except, where one of the types listed below is specifically called for on the Drawings, only that type shall be used. The determination of anchors equivalent to those listed below shall be on the basis of test data performed by an approved independent testing laboratory.

b. Adhesive anchors shall consist of threaded rods or bolts anchored with an adhesive system into hardened concrete. Adhesive anchors shall be two part injection type using the manufacturer's static mixing nozzle and shall be supplied as an entire system.

2. Unless otherwise noted, all concrete anchors which are submerged or are used in hanging items or have direct tension induced upon them, or which are subject to vibration from equipment such as pumps and generators, shall be adhesive anchors.

3. Adhesive anchors shall conform to the requirements of ACI 355.4 or alternately to AC 308. Expansion, concrete screw or mechanical anchors shall conform to the requirements of ACI 355.2 or alternately to AC 193. Anchors in Seismic Design Categories C through F shall conform to the International Building Code and ACI 318 Chapter 17 requirements as applicable, including seismic test requirements.

4. Fire Resistance: All anchors installed within fire resistant construction shall either be enclosed in a fire resistant envelope, be protected by approved fire-resistive materials, be used to resist wind and earthquake loads only, or anchor non-structural elements.

5. Engineer's approval is required for use of concrete anchors in locations other than those shown on the Drawings.

B. Concrete Anchor Design:

An anchor design consists of specifying anchor size, quantity, spacing, edge distance and embedment to resist all applicable loads. Where an anchor design is indicated on the Drawings, it shall be considered an engineered design and anchors shall be installed to the prescribed size, spacing, embedment depth and edge distance. If all parts of an

anchor design are provided on the Drawings except embedment depth, the anchors will be considered an engineered design and the Contractor shall provide the embedment depth as indicated in Paragraph B.3 unless otherwise directed by the Engineer.

1. Embedment Depth

    a. Minimum anchor embedment shall be as indicated on the Drawings.

    b. Where the embedment depth is not shown on the Drawings, concrete anchors shall be embedded no less than the manufacturer's standard embedment (expansion or mechanical anchors) or to provide a minimum allowable bond strength equal to the allowable yield capacity of the rod according to the manufacturer (adhesive anchors).

C. Structural Anchors:

1. Adhesive Anchors:

    a. Adhesive anchors shall be "Epcon C6+ Adhesive Anchoring System" by ITW Redhead, "HIT HY-200 Adhesive Anchoring System" by Hilti, Inc., "SET-XP Epoxy Adhesive Anchors" by Simpson Strong-Tie Co., or "Pure 110+ Epoxy Adhesive Anchor System" by DeWalt.

    b. Structural adhesive anchor systems shall be IBC compliant and capable of resisting short term wind and seismic loads (Seismic Design Categories A through F) as well as long term and short term sustained static loads in both cracked and uncracked concrete in all Seismic Design Categories. Structural adhesive anchor systems shall comply with the latest revision of ICC-ES Acceptance Criteria AC308, and shall have a valid ICC-ES report in accordance with the applicable building code.

D. Non-Structural Anchors: In addition to the acceptable non-structural anchors listed below, all structural anchors listed above may also be used as non-structural anchors.

1. Mechanical Anchors:

    a. Wedge Anchors: Wedge anchors shall be "Kwik Bolt 3" by Hilti, Inc., "Power-Stud+ SD1" by DeWalt, "Wedge-All" by Simpson Strong-Tie Co. or "TruBolt" by ITW Redhead.

    b. Screw Anchors: Screw anchors shall be "Kwik HUS" by Hilti, Inc., "Screw Bolt+" or 316 Stainless Steel Wedge-Bolt" by DeWalt, "Large Diameter Tapcon (LDT) Anchor" by ITW Redhead, or "Titen HD" by Simpson Strong-Tie Co. Bits specifically provided by manufacturer of chosen system shall be used for installation of anchors.

    c. Sleeve Anchors: Sleeve anchors shall be "HSL Heavy Duty Sleeve Anchors" by Hilti, Inc. "Power-Bolt+" by DeWalt "Dynabolt Sleeve Anchor" by ITW Redhead, or "Sleeve-All" by Simpson Strong-Tie Co.

d. Drop-In Anchors: Drop-in anchors shall be “Drop-In” by Simpson Strong-Tie Co., “HDI Drop-In Anchor” by Hilti, Inc., “Smart DI” by DeWalt or “Multi-Set II Drop-In Anchor” by ITW Redhead.

e. Undercut Anchors: Undercut anchors shall be “HDA Undercut Anchor” by Hilti, Inc., “Atomic Undercut+” by DeWalt or “Torq-Cut” by Simpson Strong-Tie Co.

2. Adhesive Anchors:

a. Adhesive anchors shall be “Epcon A7” or “Epcon C6+ Adhesive Anchoring System” by ITW Redhead, “HIT HY-200 Adhesive Anchoring System” by Hilti, Inc., “SET Epoxy Tie High Strength Anchoring Adhesive” or “AT High Strength Anchoring Adhesive” by Simpson Strong-Tie Co., or AC100+ Gold” Adhesive Anchoring System” by DeWalt.

b. Non-structural adhesive anchors systems shall be IBC compliant and capable of resisting short term wind and seismic (Seismic Design Categories A and B) as well as long term and short term sustained static loads in uncracked concrete.

c. Non-structural adhesive anchor embedment depth of the rod shall provide a minimum allowable bond strength that is equal to the allowable yield capacity of the rod unless noted otherwise on the Drawings.

d. **No or equal products will be considered unless prequalified and approved by the Engineer and Owner.**

E. Concrete Anchor Rod Materials:

1. Concrete anchors used to anchor structural steel shall be a threaded steel rod per manufacturer’s recommendations for proposed adhesive system, but shall not have a yield strength (fy) less than 58 ksi nor an ultimate strength (fu) less than 72.5 ksi, unless noted otherwise. Where steel to be anchored is galvanized, concrete anchors shall also be galvanized unless otherwise indicated on the Drawings.

2. Concrete anchors used to anchor aluminum, FRP, or stainless steel shall be Type 304 stainless steel unless noted otherwise. All underwater concrete anchors shall be Type 316 stainless steel.

3. Nuts, washers, and other hardware shall be of a material to match the anchors.

2.05 WELDS

A. Electrodes for welding structural steel and all ferrous steel shall comply with AWS Code, using E70 series electrodes for shielded metal arc welding (SMAW), or F7 series electrodes for submerged arc welding (SAW).

B. Electrodes for welding aluminum shall comply with the Aluminum Association Specifications and AWS D1.2.

C. Electrodes for welding stainless steel and other metals shall comply with AWS D1.6.

2.06 ANTISEIZE LUBRICANT

A. Antiseize lubricant shall be C5-A Anti-Seize by Loctite Corporation, Molykote P-37 Anti-Seize Paste by Dow Corning, 3M Anti-Seize by 3M, or equal.

PART 3 -- EXECUTION

3.01 MEASUREMENTS

A. The Contractor shall verify all dimensions and review the Drawings and shall report any discrepancies to the Engineer for clarification prior to starting fabrication.

3.02 ANCHOR INSTALLATION

A. Anchor Rods, Concrete Anchors, and Masonry Anchors

1. Anchor rods shall be installed in accordance with AISC "Code of Standard Practice" by setting in concrete while it is being placed and positioned by means of a rigidly held template. Overhead adhesive anchors, and base plates or elements they are anchoring, shall be shored as required and securely held in place during anchor setting to prevent movement during anchor installation. Movement of anchors during curing is prohibited.

2. The Contractor shall verify that all concrete anchors have been installed in accordance with the manufacturer's recommendations and that the capacity of the installed anchor meets or exceeds the specified safe holding capacity.

3. Concrete anchors shall not be used in place of anchor rods without Engineer's approval.

4. All stainless steel threads shall be coated with antiseize lubricant.

B. High Strength Bolts

1. All bolted connections for structural steel shall use high strength bolts. High strength bolts shall be installed in accordance with AISC 348 "The 2009 RCSC Specification for Structural Joints". All bolted joints shall be Type N, snug-tight, bearing connections in accordance with AISC Specifications unless noted otherwise on the Drawings.

C. Concrete Anchors

1. Concrete at time of anchor installation shall be a minimum age of 21 days, have a minimum compressive strength of 2500 psi, and shall be at least 50 degrees F.

2. Concrete anchors designed by the Contractor shall be classified as structural or non-structural based on the requirements indicated above.

3. Concrete Anchor Testing:

   a. At all locations where concrete anchors meet the requirements for structural anchors, at least 10 percent of all concrete anchors installed shall be proof tested to the value indicated on the Drawings, with a minimum of one tested anchor per anchor group. If no test value is indicated on the Drawings but the installed anchor meets the requirements for structural anchors, the Contractor shall notify the Engineer to allow verification of whether anchor load proof testing is required.

   b. Contractor shall submit a plan and schedule indicating locations of anchors to be proof tested, load test values and proposed anchor testing procedure (including a diagram of the testing equipment proposed for use) to the Engineer for review prior to conducting any testing. Proof testing of anchors shall be in accordance with ASTM E488 for the static tension test. If additional tests are required, inclusion of these tests shall be as stipulated on Contract Drawings.

   c. Concrete Anchors shall have no visible indications of displacement or damage during or after the proof test. Concrete cracking in the vicinity of the anchor after loading shall be considered a failure. Anchors exhibiting damage shall be removed and replaced. If more than 5 percent of tested anchors fail, then 100 percent of anchors shall be proof tested.

   d. Proof testing of concrete anchors shall be performed by an independent testing laboratory hired directly by the Contractor and approved by the Engineer. The Contractor shall be responsible for costs of all proof testing, including additional testing required due to previously failed tests.

4. All concrete anchors shall be installed in strict conformance with the manufacturer's printed installation instructions. A representative of the manufacturer shall be on site when required by the Engineer.

5. All holes shall be drilled in accordance with the manufacturer's instructions except that cored holes shall not be allowed unless specifically approved by the Engineer. If cored holes are allowed by the manufacturer and approved by the Engineer, cored holes shall be roughened in accordance with manufacturer requirements. Thoroughly clean drill holes of all debris, drill dust, and water in accordance with the manufacturer's instructions prior to installation of adhesive and threaded rod unless otherwise recommended by the manufacturer. Degree of hole dampness shall be in strict accordance with manufacturer recommendations. Installation conditions shall be either dry or water-saturated. Water filled or submerged holes shall not be permitted unless specifically approved by the Engineer. Injection of adhesive into the hole shall be performed to minimize the formation of air pockets in accordance with the manufacturer's instructions. Wipe rod free from oil that may be present from shipping or handling.

6. All adhesive anchor installations in the horizontal to vertically overhead orientation shall be conducted by a certified Adhesive Anchor Installer as certified by

ACI/CSRI per ACI 318-11 9.2.2. Current AAI Certificate must be submitted to the Engineer of Record prior to commencement of any adhesive anchor installations

D. Other Bolts

1. All dissimilar metal shall be connected with appropriate fasteners and shall be insulated with a dielectric or approved equal.

2. All stainless steel bolts shall be coated with antiseize lubricant.

3.03 WELDING

A. All welding shall comply with AWS Code for procedures, appearance, quality of welds, qualifications of welders and methods used in correcting welded work.

B. Welded stud connectors shall be installed in accordance with AWS D1.1.

3.04 INSPECTION

A. High strength bolting will be visually inspected in accordance with AISC 348 "The 2009 RCSC Specification for Structural Joints". Rejected bolts shall be either replaced or retightened as required.

B. Field welds will be visually inspected in accordance with AWS Codes. Inadequate welds shall be corrected or redone as required in accordance with AWS Codes.

C. Post-installed concrete anchors shall be inspected as required by ACI 318.

3.05 CUTTING OF EMBEDDED REBAR

A. The Contractor shall not cut embedded rebar cast into structural concrete during installation of post-installed fasteners without prior approval of the Engineer.

- END OF SECTION -

SECTION 05061

STAINLESS STEEL

PART 1 -- GENERAL

1.01 SECTION INCLUDES

A. The Contractor shall furnish, install and erect the stainless steel work as shown on the Contract Drawings and specified herein.

B. Stainless steel work shall be furnished complete with all accessories, mountings and appurtenances of the type of stainless steel and finish as specified or required for a satisfactory installation.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 01300 - Submittals

B. Section 05010 - Metal Materials

C. Section 05050 - Metal Fastening

D. Section 05500 - Metal Fabrications

1.03 REFERENCES

A. ASTM A193 - Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service.

B. ASTM A194 - Carbon and Alloy Steel Nuts for Bolts for High-Pressure and High-Temperature Service.

C. ASTM A262 - Practice for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steel.

D. ASTM A276 - Stainless and Heat-Resisting Steel Bars and Shapes.

E. ASTM A314 - Stainless and Heat-Resisting Steel Billets and Bars for Forging.

F. ASTM A380 - Practice for Cleaning and Descaling Stainless Steel Parts, Equipment and Systems.

G. ASTM A473 - Stainless and Heat-Resisting Steel Forgings.

H. ASTM A666 - Austenitic Stainless Steel, Sheet, Strip, Plate and Flat Bar.

I. ASTM A774 - Stainless Steel Pipe Fittings

J. ASTM A778 - Stainless Steel Pipe

K. ASTM F593 - Stainless Steel Bolts, Hex Cap Screws and Studs.

L. ASTM F594 - Stainless Steel Nuts.

M. ANSI/ASME B1.1 - Unified Inch Screw Thread (UN and UNR Thread Form).

1.04 TESTS

A. All stainless steel materials including stainless test welds, shall be checked for compliance with tests for susceptibility to intergranular attack. Such tests shall be Practices A, B and E of ASTM A262. Detailed procedures for the tests shall be submitted to the Engineer for approval prior to start of work. Practice A shall be used only for acceptance of materials but not for rejection of materials, and shall be used for screening material intended for testing in Practice B and Practice E. The maximum acceptable corrosion rate under Practice B shall be 0.004 inch per month, rounded off to the third decimal place. If the certified mill report indicates that such test has been satisfactory performed, the fabricator may not be required to repeat the test. Material passing Practice E shall be acceptable.

B. Sample selection for the susceptibility to intergranular attack tests shall be as follows:

1. One (1) sample per heat treatment lot for plates and forgings;

2. One (1) sample per each Welding Procedure Qualification regardless of the joint design;

3. If tests indicate a reduction in corrosion resistance, welding procedure shall be adjusted or heat treatment determined as needed to restore required corrosion resistance.

4. The samples so chosen shall have received all the post-weld heat treatments identical to the finished part.

1.05 SUBMITTALS

A. The Contractor shall prepare and submit for approval shop drawings for all stainless steel fabrication in accordance with Section 01300, Submittals.

B. Submittals shall include, but not be limited to, the following:

1. Certified test reports for susceptibility to intergranular attack.

2. Affidavit of compliance with type of stainless steel shown on the Contract Drawings or specified herein.

3. Certified weld inspection reports.

4. Cleaning and handling of stainless steel in accordance with Paragraph 3.04,

Cleaning and Handling.

C. Samples of finish, on each type of stainless steel to be furnished, shall be submitted to the Engineer upon request.

1.06 QUALITY ASSURANCE

A. Shop inspections may be made by the Engineer. The Contractor shall give ample notice to the Engineer prior to the beginning of any stainless steel fabrication work so that inspection may be provided. The Contractor shall furnish all facilities for the inspection of materials and workmanship in the shop, and the inspectors shall be allowed free access to the necessary parts of the works.

B. Inspectors shall have the authority to reject any materials or work which does not meet the requirements of the Contract Drawings or the Specifications.

C. Inspection at the shop is intended as a means of facilitating the work and avoiding errors, but is expressly understood that it will in no way relieve the Contractor from his responsibility for furnishing proper materials or workmanship.

1.07 HANDLING, STORAGE AND DELIVERY

A. Mechanical damage (e.g., scratches and gouges) to the stainless steel material shall not be permitted and is cause for rejection. Care shall be taken in the material handling since such mechanical damage will result in the passive oxide film being "punctured" leading to a possible lower resistance to the initiation of corrosion than the surrounding chemically-passivated surface.

B. Stainless steel plates and sheets shall be stored vertically in racks and not be dragged out of the racks or over one another. Racks shall be protected to prevent iron contamination.

C. Heavy stainless steel plates shall be carefully separated and chocked with wooden blocks so that the forks of a fork-lift could be inserted between plates without mechanically damaging the surface.

D. Stainless steel plates and sheets laid out for use shall be off the floor and be divided by wooden planks to prevent surface damage and to facilitate subsequent handling.

E. Plate clamps, if used, shall be used with care as the serrated faces can dig in, indent and gouge the surface.

F. Stainless steel fabrications shall be loaded in such a manner that they may be transported and unloaded without being overstressed, deformed or otherwise damaged.

G. Stainless steel fabrications and packaged materials shall be protected from corrosion and deterioration and shall be stored in a dry area. Materials stored outdoors shall be supported above ground surfaces on wood runners and protected with approved effective and durable covers.

H. Stainless steel fabrications shall not be placed in or on a structure in a manner that might cause distortion or damage to the fabrication. The Contractor shall repair or replace damaged stainless steel fabrications or materials as directed by the Engineer.

1.08 FIELD MEASUREMENTS

A. The Contractor shall verify all dimensions and shall make any field measurements necessary and shall be fully responsible for accuracy and layout of the work.

B. The Contractor shall review the Contract Drawings and any discrepancies shall be reported to the Engineer for clarification prior to starting fabrication.

## PART 2 -- PRODUCTS

2.01 MATERIALS AND FINISHES

A. Stainless steel shall be Type 304 unless it is used for underwater service. Stainless steel for underwater service shall be Type 316. Minimum mechanical finish shall be No. 4 as stated in Table 2 unless otherwise noted on the Contract Drawings.

B. The basic mill forms (sheet, strip, plate and bar) are classified by size as shown on Table 1. Tables 2, 3 and 4 identify finishes and conditions in which sheet, bar and plate are available.

C. Tables 2, 3 and 4 show numbered finishes and conditions for sheet, bar and plate. While there are no specific designations for polished finishes on bar or plate, the sheet finish designations are used to describe the desired effect. This also applies to finishes on ornamental tubing.

D. There are three standard finishes for strip, which are broadly described by the finishing operations employed:

1. No. 1 Strip Finish

   No. 1 strip finish is approximately the same as No. 2D Sheet Finish. It varies in appearance from dull gray matte to a fairly reflective surface, depending largely on alloy composition and amount of cold reduction.

2. No. 2 Strip Finish is approximately the same as a No. 2B sheet finish. It is smoother, more reflective than No. 1, and likewise varies with alloy composition.

3. Bright annealed finish is a highly reflective finish that is retained by final annealing in a controlled atmosphere furnace.

**Table 1**

**Classification of Stainless Steel Product Form**

| Item | Description | Dimensions | | |
|---|---|---|---|---|
| | | Thickness | Width | Diameter or Size |
| Sheet | Coils and cut length:<br>Mill finishes Nos. 1, 2D and 2B<br>Polished finishes Nos. 3, 4, 6, 7 & 8 | <br>under 3/16"<br>under 3/16" | <br>24" and over<br>all widths | <br>--<br>-- |
| Strip | Cold finished, coils or cut lengths<br>Polished finishes Nos. 3, 4, 6,7 & 8 | under 3/16"<br>under 3/16" | under 24"<br>all widths | --<br>-- |
| Plate | Flat rolled or forged | 3/16" and over | over 10" | -- |
| Bar | Hot finished rounds, squares, octagons and hexagons<br>Hot finished flats<br><br>Cold finished rounds, squares, octagons and hexagons<br>Cold finished flats | --<br>1/8" to 8" incl.<br><br>--<br>1/8" to 4-1/2" | --<br>1/4" to 10" incl.<br><br>--<br>3/8" to 4-1/2" | 1/4" and over<br>--<br><br><br>over 1/8"<br>-- |
| Wire | Cold finishes only: (in coil)<br>Round, square, octagon, hexagon and flat wire | <br>under 3/16" | <br>under 3/8" | <br>-- |
| Pipe & Tubing | Several different classifications, with differing specifications, are available. | | | |
| Extrusion | Not considered “standard” shapes. Currently limited in size to approximately 6-1/2" diameter or structurals. | | | |

**Table 2**

**Standard Mechanical Sheet Finishes**

| | |
|---|---|
| **Unpolished or Rolled Finishes:**<br>No. 1 A rough dull surface which results from hot rolling to the specified thickness followed by annealing and descaling. | No. 4 A polished surface obtained by finishing with a 120-150 mesh abrasive, following initial grinding with coarser abrasives. This is a general purpose bright finish with a visible "grain" which prevents mirror reflection. |
| No. 2D A dull finish which results from cold rolling followed by annealing and descaling, and may perhaps get a final light roll pass through unpolished rolls. A 2D finish is used where appearance is of no concern. | No. 6 A dull satin finish having lower reflectivity than No. 4 finish. It is produced by Tampico brushing the No. 4 finish in a medium of abrasive and oil. It is used for architectural applications and ornamentation where a high luster is undesirable, and to contrast with brighter finishes. |
| No. 2B A bright cold-rolled finish resulting in the same manner as No. 2D finish, except that the annealed and descaled sheet receives a final light roll pass through polished rolls. This is the general purpose cold-rolled finish that can be used as is, or as a preliminary step to polishing. | No. 7 A high reflective finish that is obtained by buffing finely ground surfaces but not to the extent of completely removing the "grit" lines. It is used chiefly for architectural and ornamental purposes. |
| **Polished Finishes**:<br>No. 3 An intermediate polish surface obtained by finishing with a 100 grit abrasive. Generally used where a semi-finished polished surface is required. A No. 3 finish usually receives additional polishing during fabrication. | No. 8 The most reflective surface, which is obtained by polishing with successively finer abrasives and buffing extensively until all grit lines from preliminary grinding operations are removed. It is used for applications such as mirrors and reflectors. |

**Table 3**

**Conditions and Finishes for Bar**

| Conditions | Surface Finishes[1] |
|---|---|
| Hot worked only | (a) Scale not removed (excluding spot conditioning)<br>(b) Rough turned[2]<br>(c) Pickled or blast cleaned and pickled. |
| Annealed or otherwise heat treated. | (a) Scale not removed (excluding spot conditioning)<br>(b) Rough turned<br>(c) Pickled or blast cleaned and pickled<br>(d) Cold drawn or cold rolled<br>(e) Centerless ground<br>(f) Polished |
| Annealed and cold worked to high tensile strength[3] | (d) Cold drawn or cold rolled<br>(e) Centerless ground<br>(f) Polished |

1 Surface finishes (b), (e) and (f) are applicable to round bars only.

2 Bars of the 4xx series stainless steels which are highly hardenable, such as Types 414, 420, 420F, 431, 440A, 440B and 440C, are annealed before rough turning. Other hardenable grades, such as Types 403, 410, 416 and 416Se, may also require annealing depending on their composition and size.

3 Produced in Types 302, 303Se, 304 and 316.

**Table 4**

**Conditions and Finishes for Plate**

| Condition and Finish | Description and Remarks |
|---|---|
| Hot rolled | Scale not removed. Not heat treated. Plates not recommended for final use in this condition.[4] |
| Hot rolled, annealed or heat treated | Scale not removed. Use of plates in this condition is generally confined to heat resisting applications. Scale impairs corrosion resistance.[1] |
| Hot rolled, annealed or heat treated, blast cleaned or pickled | Condition and finish commonly preferred for corrosion resisting and most heat resisting applications. |
| Hot rolled, annealed, descaled and temper passed | Smoother finish for specialized applications. |
| Hot rolled, annealed, descaled cold rolled, annealed, descaled, optionally temper passed | Smooth finish with greater freedom from surface imperfection than the above. |
| Hot rolled, annealed or heat treated, surface cleaned and polished | Polished finishes refer to Table 2. |

[4] Surface inspection is not practicable on plates which have not been pickled or otherwise descaled.

PART 3 -- EXECUTION

3.01 FABRICATION

A. Holes for bolts and screws shall be drilled. Fastenings shall be concealed where practicable. Joints exposed to the weather shall be formed to exclude water.

B. As far as practicable, all fabricated units shall be fitted and assembled in the shop, with all cuts and bends made to precision measurements in accordance with details shown on approved shop drawings.

C. Work shall be fabricated so that it is installed in a manner that will provide for expansion and contraction, prevent the shearing of bolts, screws and other fastenings, ensure rigidity, and provide close fitting of sections.

D. All finished and/or machined faces shall be true to line and level. Stainless steel sections shall be well formed to shape and size with sharp lines and angles; curved work shall be sprung evenly to curves.

E. All work shall be fitted together at the shop as far as possible, and delivered complete and ready for erection. Proper care shall be exercised in handling all work so as not to

injure the finished surfaces.

3.02 WELDING

A. Welding shall be done in a manner that will prevent buckling and in accordance with Specification 05050 – Metal Fastening, and as modified hereinafter.

B. All welds exposed in the work shall be ground smooth and finished to match the finish of the adjacent stainless steel surfaces.

C. Select weld rods that provide weld filler metal having corrosion resistant properties as nearly identical or better than the base metal to insure preservation of the corrosion-resistant properties. Provide heat treatment at welds where testing of weld procedure indicates it is required to restore the corrosion resistance.

D. Thermal conductivity of stainless steel is about half that of other steels; and the following methods may be used to accommodate this situation:

1. Use lower weld current setting.

2. Use skip-weld techniques to minimize heat concentration.

3. Use back-up chill bars or other cooling techniques to dissipate heat.

E. Edges of the stainless steel to be welded shall be cleaned of contaminants.

3.03 FASTENERS

A. Stainless steel fasteners shall be used for joining stainless steel work.

B. Stainless steel fasteners shall be made of alloys that are equal to or more corrosion resistant than the materials they join.

3.04 CLEANING AND HANDLING

A. All stainless steel surfaces shall be precleaned, descaled, passivated and inspected before, during and after fabrication in accordance with the applicable sections of ASTM A380 and as detailed in the procedures to be submitted to the Engineer for approval prior to start of work. Degreasing and passivation of stainless steel articles shall be conducted as the last step after fabrication.

B. Measures to protect cleaned surfaces shall be taken as soon as final cleaning is completed and shall be maintained during all subsequent handling, storage and shipping.

1. The Contractor shall submit for approval specific procedures listing all the steps to be followed in detecting contamination and in descaling, cleaning, passivation and protecting of all stainless steel.

2. Area showing clear indications of contamination shall be recleaned, repassivated and reinspected.

C. At approved stages in the shop operations, contaminants such as scale, embedded iron, rust, dirts, oil, grease and any other foreign matter shall be removed from the metal, as directed or approved by the Engineer. The adequacy of these operations shall be checked by the Engineer. Operations in the shop shall be conducted so as to avoid contamination of the stainless steel and to keep the metal surfaces free from dirt and foreign matter.

D. In order to prevent incipient corrosion during fabrication, special efforts shall be made at all times to keep all stainless steel surfaces from coming in contact with other metals.

1. Stainless steel and stainless steel welds shall be cleaned with clean sand free of iron, stainless steel wool, stainless steel brushes, or other approved means and shall be protected at all times from contamination by any materials, including carbon steel, that shall impair its resistance to corrosion.

2. Approved methods of cutting, grinding and handling shall be used to prevent contamination. If air-arc, or carbon-arc cutting is used, additional metal shall be removed by approved mechanical means so as to provide clean, weldable edges. All grinding of stainless steel shall be performed with aluminum oxide or silicon carbide grinding wheels bonded with resin or rubber. Grinding wheels used on carbon steel shall not be used on stainless steel.

3. Sand, grinding wheels, brushes and other materials used for cleaning stainless steel shall be checked periodically by the Engineer for contaminants. Cleaning aids found to contain contaminants shall not be used on the work.

3.05 INSTALLATION

A. All stainless steel fabrications shall be erected square, plumb and true, accurately fitted, adequately anchored in place, set at proper elevations and positions.

B. All inserts, anchor rods and all other miscellaneous work specified in the Detailed Specifications or shown on the Contract Drawings or required for the proper completion of the work, which are embedded in concrete, shall be properly set and securely held in position in the forms before the concrete is placed.

C. All stainless steel fabrications shall be installed in conformance with details shown on the Contract Drawings or on the approved shop drawings.

-END OF SECTION -

SECTION 05120

STRUCTURAL STEEL

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Furnish all equipment, labor, materials, and services required to provide all structural steel work in accordance with the Contract Documents. The term "structural steel" shall include items as defined in the AISC "Code of Standard Practice".

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 05010 - Metal Materials

B. Section 05035 - Galvanizing

C. Section 05050 - Metal Fastening

1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Without limiting the generality of the Specifications, all work specified herein shall conform to the applicable requirements of the following documents.

1. International Building Code 2015.

2. AISC - "Code of Standard Practice."

3. AISC - "Specification for Structural Steel Buildings".

4. AISC 348 - "The 2009 RCSC Specification for Structural Joints".

5. AWS - "Structural Welding Code".

1.04 SUBMITTALS

A. Submit the following in accordance with Section 01300, Submittals.

1. Certified Mill Test Reports

2. Affidavit of Compliance with grade specified

3. Shop Drawings which include the following:

a. Layout drawings indicating all structural shapes, sizes, and dimensions.

b. Beam and column schedules.

c. Detailed drawings indicating jointing, anchoring and connection details and vent and drain holes where required.

1.05 QUALITY ASSURANCE

A. Shop inspection may be required by the Owner at his own expense. The Contractor shall give ample notice to the Engineer prior to the beginning of any fabrication work so that inspection may be provided. The Contractor shall furnish all facilities for the inspection of materials and workmanship in the shop, and the inspectors shall be allowed free access to the necessary parts of the work. Inspectors shall have the authority to reject any materials or work which do not meet the requirements of these Specifications. Inspection at the shop is intended as a means of facilitating the work and avoiding errors, but is expressly understood that it will in no way relieve the Contractor from his responsibility for furnishing proper materials or workmanship under this Specification.

B. The erector shall be a qualified installer who participates in the AISC Certification program and is designated an AISC Certified Erector, Category ACSE.

C. The fabricator shall be a qualified fabricator who participates in the AISC Certification program and is designated an AISC Certified Plant, Category STD**.**

PART 2 -- PRODUCTS

2.01 MATERIALS

A. Structural Steel

1. Structural steel for W shapes shall conform to ASTM A992 unless otherwise indicated.

2. Structural steel for HP shapes shall conform to ASTM A572 Grade 50 unless otherwise indicated.

3. Structural steel for S, M, C, and MC shapes and angles and plates shall conform to ASTM A36 unless otherwise indicated.

4. Steel pipe shall be ASTM A53, Grade B.

5. HSS shall be ASTM A500, Grade C or ASTM A1085. All members shall be furnished full length without splices unless otherwise noted or accepted by the Engineer.

6. All unidentified steel will be rejected and shall be removed from the site and replaced by the Contractor, all at the expense of the Contractor.

7. Fasteners for structural steel shall be in accordance with Section 05050, Metal Fastening.

B. Welds

1. Electrodes for welding shall be in accordance with Section 05050, Metal Fastening.

## PART 3 -- EXECUTION

### 3.01 MEASUREMENT

A. The Contractor shall verify all dimensions and shall make any field measurements necessary and shall be fully responsible for accuracy and layout of work. The Contractor shall review the Drawings and any discrepancies shall be reported to the Engineer for clarification prior to starting fabrication.

### 3.02 FABRICATION

A. Fabrication shall be in accordance with the AISC "Specification for Structural Steel Buildings" and AISC "Code of Standard Practice". Fabrication shall begin only after Shop Drawing approval.

B. Except where otherwise noted on the Drawings or in this Specification, all shop connections shall be welded.

C. All holes in structural steel members required for anchors, anchor rods, bolts, sag rods, vent and drain holes or other members or for attachment of other work shall be provided by the fabricator and detailed on the Shop Drawings.

D. All materials shall be properly worked and match-marked for field assembly.

E. Where galvanizing of structural steel is required, it shall be done in accordance with Section 05035, Galvanizing.

### 3.03 DELIVERY, STORAGE AND HANDLING

A. Structural members shall be loaded in such a manner that they may be transported and unloaded without being over-stressed, deformed or otherwise damaged.

B. Structural steel members and packaged materials shall be protected from corrosion and deterioration. Material shall be stored in a dry area and shall not be placed in direct contact with the ground. Materials shall not be placed on the structure in a manner that might cause distortion or damage to the members or the supporting structures. The Contractor shall repair or replace damaged materials or structures as directed.

### 3.04 ERECTION

A. The erection of all structural steel shall conform to the applicable requirements of the AISC "Specification for Structural Steel Buildings" and AISC "Code of Standard Practice". All temporary bracing, guys and bolts as may be necessary to ensure the safety of the structure until the permanent connections have been made shall be provided by the Contractor.

B. Structural members shall be set accurately to the lines and elevations indicated. The various members shall be aligned and adjusted to form a part of a complete frame or structure before permanently fastened. A licensed land surveyor shall survey the structural steel during erection and shall provide a final survey indicating elevations and locations of all major members. Necessary adjustments to compensate for discrepancies in elevations and alignments shall be performed.

C. No cutting of structural steel members in the field will be allowed except by the written approval of the Engineer.

D. Bearing surfaces and other surfaces which will be in permanent contact shall be cleaned before assembly.

E. Field welding shall not be permitted unless specifically indicated in the Drawings or approved in writing by the Engineer. All field welding shall comply with Section 05050, Metal Fastening.

F. All bolted connections shall use high strength bolts in accordance with Section 05050, Metal Fastening. High strength bolts shall be installed in accordance with AISC 348 “The 2009 RCSC Specification for Structural Joints”. Bolts specified or noted on the Drawings to be a tension or slip critical “SC” type connection shall be fully pretensioned with proper preparation of the faying surfaces. All other bolts shall be snug tightened unless otherwise noted on the Drawings.

G. All field connections shall be accurately fitted up before being bolted. Drifting shall be only such as will bring the parts into position and shall not be sufficient to enlarge the holes or to distort the metal. All unfair holes shall be drilled or reamed.

H. Misfits at Bolted Connections

1. Where misfits in erection bolting are encountered, the Engineer shall be immediately notified. The Contractor shall submit a method to remedy the misfit for review by the Engineer. The Engineer will determine whether the remedy is acceptable or if the member must be refabricated.

2. Incorrectly sized or misaligned holes in members shall not be enlarged by burning or by the use of drift pins. The Contractor shall notify the Engineer immediately and shall submit a proposed method of remedy for review by the Engineer.

3. Where misalignment between anchor rods and rod holes in steel members are encountered, the Engineer shall be immediately notified. The Contractor shall submit a method to remedy the misalignment for review by the Engineer.

I. Grouting of Base Plates and Bearing Plates

1. The bottom surface of the plates shall be cleaned of all foreign materials, and concrete or masonry bearing surface shall be cleaned of all foreign materials and roughened to improve bonding.

2. Accurately set all base and bearing plates to designated levels with steel wedges or leveling plates.

3. Baseplates shall be grouted with non-shrink grout to assure full uniform bearing. Grouting shall be done prior to placing loads on the structure. Non-shrink grout shall conform to Section 03600, Grout.

4. Anchor rods shall be tightened after the supported members have been positioned and plumbed and the non-shrink grout has attained its specified strength.

J. Where finishing is required, assembly shall be completed including bolting and welding of units before start of finishing operations.

3.05 PAINTING

A. Painting shall be performed according to Section 09900, Painting and the following additional requirements.

1. Contact Surfaces: Contact surfaces such as at field connections, shall be cleaned and primed but not painted.

2. Finished Surfaces: Machine finished surfaces shall be protected against corrosion by a rust-inhibiting coating which is easily removed prior to erection or which has characteristics that make removal unnecessary prior to erection.

3. Surfaces Adjacent to Field Welds: Surfaces within 2 inches of any field weld location shall be free of materials that would prevent proper welding or produce objectionable fumes while welding is being done.

- END OF SECTION -

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SECTION 05500

METAL FABRICATIONS

PART 1 -- GENERAL

1.01 REQUIREMENT

A. Furnish all materials, labor, and equipment required to provide all metal fabrications not specifically included in other Sections, complete and in accordance with the requirements of the Contract Documents.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 05010 - Metal Materials

B. Section 05050 - Metal Fastening

C. Section 05035 - Galvanizing

D. Certain specific items are included in other Sections of the Specifications. See the section for the specific item in question.

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Without limiting the generality of other requirements of the Specifications, all work specified herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.

1. International Building Code 2015.

2. AISC - Specification for Structural Steel Buildings

3. AISI - Specifications for the Design of Cold-Formed Steel Structural Members

4. Aluminum Association Specifications for Aluminum Structures

1.04 SUBMITTALS

A. Submit the following in accordance with Section 01300, Submittals.

1. Complete fabrication and erection drawings of all metalwork specified herein.

2. Other submittals as required in accordance with Section 05010, Metal Materials, and Section 05050, Metal Fastening.

PART 2 -- PRODUCTS

2.01 METAL MATERIALS

A. Metal materials used in metal fabrications shall conform to Section 05010, Metal Materials, unless noted otherwise.

2.02 METAL FASTENING

A. All welds and fasteners used in metal fabrication shall conform to Section 05050, Metal Fastening, unless noted otherwise.

PART 3 -- EXECUTION

3.01 FABRICATION

A. All measurements and dimensions shall be based on field conditions and shall be verified by the Contractor prior to fabrication. Such verification shall include coordination with adjoining work.

B. All fabricated work shall be shop fitted together as much as practicable, and delivered to the field, complete and ready for erection. All miscellaneous items such as stiffeners, fillets, connections, brackets, and other details necessary for a complete installation shall be provided.

C. All work shall be fabricated and installed in a manner that will provide for expansion and contraction, prevent shearing of bolts, screws, and other fastenings, ensure rigidity, and provide a close fit of sections.

D. Finished members shall conform to the lines, angles, and curves shown on the Drawings and shall be free from distortions of any kind.

E. All shearings shall be neat and accurate, with parts exposed to view neatly finished. Flame cutting is allowed only when performed utilizing a machine.

F. All shop connections shall be welded unless otherwise indicated on the Drawings or specified herein. Bolts and welds shall conform to Section 05050, Metal Fastening. All fastenings shall be concealed where practicable.

G. Fabricated items shall be shop painted when specified in Section 09900, Painting.

3.02 INSTALLATION

A. Assembly and installation of fabricated system components shall be performed in strict accordance with manufacturer's recommendations.

B. All miscellaneous metalwork shall be erected square, plumb and true, accurately fitted, adequately anchored in place, and set at proper elevations and positions

C. Metal work shall be field painted when as specified in accordance with Section 09900, Painting.

- END OF SECTION -

SECTION 05531

GRATINGS, ACCESS HATCHES, AND ACCESS DOORS

## PART 1 -- GENERAL

### 1.01 THE REQUIREMENT

A. Furnish all materials, labor, and equipment required to provide all gratings, floor plates, and hatches in accordance with the Contract Documents.

### 1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 05010 - Metal Materials

B. Section 05035 - Galvanizing

C. Section 05050 - Metal Fastening

### 1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.

1. International Building Code 2015.

2. Aluminum Association Specifications for Aluminum Structures

3. Occupational Safety and Health Administration (OSHA) Regulations

### 1.04 SUBMITTALS

A. Submit the following in accordance with Section 01300, Submittals.

1. Complete fabrication and erection Drawings of all gratings, access hatches, and access doors specified herein.

2. Other submittals as required in accordance with Section 05010, Metal Materials, and Section 05050, Metal Fastening.

## PART 2 -- PRODUCTS

### 2.01 METAL MATERIALS

A. Metal materials used for gratings, floor plates, and hatches shall conform to Section 05010, Metal Materials, unless noted otherwise.

2.02 METAL FASTENING

A. All welds and fasteners used for gratings, floor plates, and hatches shall conform to Section 05050, Metal Fastening, unless noted otherwise.

2.04 ACCESS HATCHES

A. Access hatches shall be aluminum unless noted otherwise.

B. All access hatches shall be checker plate with an approved raised pattern, non-skid surface.

C. Unless otherwise noted on the contract drawings; access hatches shall be designed to carry a minimum live load of 150 psf, or a concentrated load of 300 pounds at the center, whichever produces the greatest stress.

D. Access hatches shall not exceed an allowable fiber stress of 16,000 psi. Live load deflection shall be limited to L/240 of the span, but not more than 1/4-inch.

E. All access hatches shall be fabricated from 1/4" plate, minimum and shall be stiffened as required to maintain allowable stress and deflection requirements specified herein. Stiffeners shall consist of angles or bars welded to the bottom of the plate.

F. Hinges, where indicated on the Drawings, shall be insulated, heavy-duty, cadmium plated bronze with stainless steel pins and fasteners.

G. All access hatches as indicated on the Drawings shall be provided with recessed handles. Handle material shall be as shown on the Contract Drawings.

H. Air-tight and water-tight access hatches shall be provided with a 1/8 inch thick neoprene gasket between the checkered plate and the support frame. Gasket material shall be bonded to the support frame and access hatches shall be bolted to the structural support frame with countersunk stainless steel flathead screws.

2.05 ACCESS DOORS

A. General

1. Door opening sizes, number and direction of swing of door leaves, and locations shall be as shown on the Drawings. The Drawings shall indicate the clear opening dimensions.

2. All doors shall be aluminum unless otherwise noted.

3. Openings larger than 48 inches in either direction shall have double leaf doors.

4. Doors shall be designed for flush mounting and for easy opening from both inside and outside.

5. All doors shall be provided with an automatic hold-open arm with release handle.

6. Double leaf doors shall be provided with safety bars to go across the open sides of the door, when in the open position. Brackets shall be provided on the underside of the doors to hold the safety bars when not in use.

7. All hardware, including but not limited to, all parts of the latch and lifting mechanism assemblies, hold open arms and guides, brackets, hinges, springs, pins, and fasteners shall be stainless steel.

8. All doors shall be watertight with a continuous gasket. All single door applications shall include a continuous EPDM odor reduction gasket.

9. Door frames shall be extruded and equipped with a 1-1/2 inch minimum drain pipe located by the manufacturer. The drain pipe shall be provided by the Contractor and shall extend to the nearest point of discharge acceptable to the Engineer.

B. Floor, Wet Well and Dry Pit Access Doors

1. Door leaves shall be 1/4 inch, minimum, diamond pattern plate with an approved raised pattern, non-skid surface. Plate shall be stiffened as required to maintain allowable stress and deflection requirements. Stiffeners shall consist of angles or bars welded to the bottom of plate.

2. Doors shall be designed for a 300 psf live load minimum, unless noted otherwise on the contract drawings.

3. Doors shall be designed for flush mounting and for easy opening from both inside and outside.

4. All doors shall have an enclosed compression spring assist and open to 90 degrees.

5. Exterior doors shall be Type "J-AL" or "JD-AL", by Bilco Company, Type ”W1S” or “W2S” by Halliday Products Inc., Type "TPS" or "TPD", by U.S.F. Fabrication Inc., Type "THG" or "THG-D", by Thompson Fabricating LLC.

6. Interior doors shall be Type "K" or "KD", by Bilco Company, Type ”S1S” or “S2S” by Halliday Products Inc., Type "APS300" or "APD300", by U.S.F. Fabrication Inc., Type "TH" or "TH-D", by Thompson Fabricating LLC.

7. Doors rated for H-20 traffic loading shall be “JAL-HD” or “JDAL-HD” by the Bilco Company, Type “H1C” or “H2C” by Halliday Products, Inc., or Type “THS” or “THD” by U.S.F. Fabrication Inc.

C. Roof Access Doors

1. Doors shall be designed for 50 psf live load unless noted otherwise.

2. Doors for service stairs shall be Bilco Type L roof Scuttles.

3. Doors for ladder access shall be Bilco Type S or SS Roof Scuttles.

2.06 FALL THROUGH PREVENTION SYSTEM

A. All access hatches and access doors covering openings measuring 12 inches or more in its least dimension through which persons may fall shall be equipped with a fall through prevention system, except where noted on the Contract Drawings. Access hatches and access doors shall be provided with a permanent installed fall through prevention grate system that provides continuous safety assurance in both its closed and open positions.

## PART 3 -- EXECUTION

### 3.01 FABRICATION

A. All measurements and dimensions shall be based on field conditions and shall be verified by the Contractor prior to fabrication. Such verification shall include coordination with adjoining work.

B. All fabricated work shall be shop fitted together as much as practicable, and delivered to the field, complete and ready for erection. All miscellaneous items such as stiffeners, fillets, connections, brackets, and other details necessary for a complete installation shall be provided.

C. All work shall be fabricated and installed in a manner that will provide for expansion and contraction, prevent shearing of bolts, screws, and other fastenings, ensure rigidity, and provide a close fit of sections.

D. Finished members shall conform to the lines, angles, and curves shown on the Drawings and shall be free from distortions of any kind.

E. All shearings shall be neat and accurate, with parts exposed to view neatly finished. Flame cutting is allowed only when performed utilizing a machine.

F. All shop connections shall be welded unless otherwise indicated on the Drawings or specified herein. Bolts and welds shall conform to Section 05050, Metal Fastening. All fastenings shall be concealed where practicable.

### 3.02 INSTALLATION

A. Assembly and installation of fabricated system components shall be performed in strict accordance with manufacturer's recommendations.

B. All gratings, access hatches, and access doors shall be erected square, plumb and true, accurately fitted, adequately anchored in place, and set at proper elevations and positions. Embedded support frames shall be set level and square.

- END OF SECTION -

SECTION 05830

BEARING DEVICES AND ANCHORING

PART 1 -- GENERAL

1.01 THE REQUIREMENTS

A. The Contractor shall furnish and install bearing plates, pads, expansion devices, anchor rods and bolts and/or other devices used in conjunction with bearings and anchoring of bearing devices and assemblies at supports in accordance with this item and in conformity with the Drawings.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 05010 - Metal Materials

B. Section 05035 - Galvanizing

C. Section 05050 - Metal Fastening

D. Section 05120 - Structural Steel

E. Section 09900 - Painting

1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Without limiting the generality of other requirements of these Specifications, all work specified hereunder shall conform to the applicable requirements of the following documents to the extent that the provisions of such documents are not in conflict with the requirements of this Section.

| | | |
|---|---|---|
| 1. | RMA Rubber Handbook | A4-F3-T.063-B2, Grade 2, Method B |
| 2. | ASTM D395, Method B | Standard Test for Rubber Property – Compression Set |
| 3. | ASTM D412 | Standard Test for Rubber Properties In Tension |
| 4. | ASTM D471 | Standard Test for Rubber Property - Effect of Liquids |
| 5. | ASTM D573 | Standard Test for Rubber-Deterioration In Air Oven |
| 6. | ASTM D575, Method A | Standard Test for Rubber Properties In Compression |
| 7. | ASTM D624, Die C | Standard Test for Rubber Property - Tear Resistance |

| | | |
|---|---|---|
| 8. | ASTM D746 | Standard Test for Brittleness Temperature of Plastics and Elastomers by Impact |
| 9. | ASTM D1149 | Standard Test for Rubber Deterioration - Surface Ozone Cracking In a Chamber (Flat Specimens) |
| 10. | ASTM D2240 | Standard Test for Rubber Property - Durometer Hardness |

1.04 SUBMITTALS

A. Submit the following in accordance with the requirements of Section 01300, Submittals:

1. Certification of compliance that the materials furnished under this section meet and conform to the property and physical requirements, including all testing, as stated herein and as referenced. Specifically, the certification shall state compliance with the applicable standards (ASTM, ANSI, etc.) for fabrication and testing.

2. Shop Drawings for all materials, including installation and adjustment instructions. Included with the Shop Drawings shall be all material certifications, mill test results, working drawings, etc., which are required by this and other applicable sections of the Specifications.

PART 2 -- PRODUCTS

2.01 ELASTOMERIC BEARING PADS

A. The elastomer portion of pads shall be new neoprene compound. Pads shall be cast under heat and pressure and may be individually molded or cut from pressure-cast stock. Variations from the dimensions shown on the Drawings shall not be more than the following: thickness, ±1/16 inch; width, -1/8 to +1/4 inch; length, -1/8 to +1/4 inch. Tolerances, dimensions, finish and appearance, flash, and rubber-to-metal bonding shall conform to the requirements of A 4-F3-T.063-B2, Grade 2, Method B, in accordance with the RMA Rubber Handbook. Pads shall be furnished in one piece and shall not be laminated unless otherwise specified. Pads shall be furnished in identifiable packages.

B. Adhesive for use with elastomer pads shall be an epoxy-resin compound compatible with the elastomer having a sufficient shear strength to prevent slippage between pads and adjacent bearing surfaces. Adhesive shall be 20$^{+}$F Contact Cement by Miracle Adhesives Corporation, Neoprene Adhesive 77-198 by IGI Adhesives, Sikodur 31, Hi-Mod Gel by Sika Corporation, or DP-605 NS Urethane Adhesive by 3M Adhesive Systems.

C. Laminated pads shall consist of alternate laminations of elastomer and hot-rolled steel sheets molded together as a unit. Outer metal laminations shall be 3/16 inch, and inner laminations shall be 14 gage. Outer laminations of elastomer shall be 1/4 inch, and inner laminations shall be of equal thickness (at least 3/8 but not more than 1/2 inch), depending on the number of laminations and thickness of the pad. Edges of metal laminations shall have a cover of approximately 1/8 inch of elastomer. The top and bottom bearing surfaces shall each have an integral sealing rib approximately 1/8 inch in depth, in addition to the specified total thickness, and 3/16 inch in width around their peripheries. The bond between the elastomer and metal shall be such that failure shall occur in the elastomer and not

between the elastomer and steel when tested for separation. Variations from specified dimensions for individual laminations shall not be more than those specified herein. The total thickness of the complete pad shall not vary more than ±1/8 inch.

D. Material having a nominal durometer hardness of 70 and 50 shall be used for nonlaminated pads and laminated pads, respectively. Test samples will be prepared from finished pads. Samples of each thickness will be taken from 2 full-size pads from each shipment of 300 pads or less, with 1 additional pad for each additional increment of 300 pads or fraction thereof. When tested using the ASTM methods designated, samples shall comply with the following physical requirements.

1. **Original Physical Properties:** Test results for tear resistance, tensile strength, and ultimate elongation shall not be more than 10 percent below the following specified value:

| | **Nominal Hardness** | |
|---|---|---|
| | **50** | **70** |
| Min. tear resistance, ASTM D624, Die C (lb/in of thickness) | 180 | 200 |
| Hardness, ASTM D2240 (points) | 50±5 | 70±5 |
| Min. tensile strength, ASTM D412 (average psi of longitudinal and transverse) | 2,500 | 2,500 |
| Min. ultimate elongation (%) | 400 | 300 |

The compressive deflection tested in accordance with ASTM D575, Method A, shall be as follows:

a. **Laminated Pads:** The maximum compression deflection shall be 5 and 7 percent of the total rubber thickness at loads of 500 and 800 pounds per square inch, respectively. The maximum shear resistance shall be 50 pounds per square inch of the plan area at 25 percent shear deformation at –20°F. Test pads shall be subjected to a compressive load of 1.5 times the maximum design load without visible damage to the bearing.

b. **Nonlaminated Pads:** When loaded within 300 to 800 pounds per square inch, material shall show a compressive deflection within 20 percent of that given in the charts of Method A, interpolating for actual measured hardness.

2. **Changes in Original Physical Properties:** When pads are oven aged 70 hours at 212°F in accordance with ASTM D573, changes shall not be more than the following:

| **Property** | **Value** |
|---|---|
| Hardness (points change) | 0 to +15 |
| Tensile strength (% change) | ±15 |
| Ultimate elongation (% change) | -40 |

3. **Extreme Temperature Characteristics:** Compression set under constant deflection, ASTM D395, Method B, 22 hours at 212°F, shall not be more than 35 percent. With the low-temperature brittleness test, ASTM D746, breaks shall not occur above –20°F.

4. **Ozone Cracking Resistance:** Upon exposure to 100 parts per million of ozone in air by volume at a strain of 20 percent and a temperature of 100±2°F in a test otherwise in accordance with ASTM D1149, cracks shall not develop within 100 hours. Samples shall be wiped with solvent before the test to remove traces of surface impurities.

5. **Oil Swell:** The volume change shall not be more than +120 percent when tested in accordance with ASTM D471 with ASTM Oil No. 3, 70 hours at 212°F.

2.02 ANCHOR RODS

A. Anchor bolts shall be as specified in Section 05050, Metal Fastening.

2.03 PIPE SLEEVES AND COLLARS

A. Pipe sleeves and collars shall be cut from schedule 40 PVC plastic pipe meeting the requirements of ASTM D1785 unless otherwise noted on the Drawings.

PART 3 -- EXECUTION

3.01 STEEL PLATES, SHAPES, AND BARS

A. Unless galvanizing is indicated on the Drawings, items shall be painted in accordance with the Drawings and Section 09900, Painting.

B. If galvanizing is indicated on the Drawings, steel bearing assemblies for both structural steel beams and girders and prestressed concrete members shall be galvanized as specified in Section 05035, Galvanizing. Except for attachments of bearing plates to beams, all fabrication and welding of bearing plate assemblies shall be performed before the steel is galvanized. All joints of welded parts shall be sealed with weld material. Welds made for attaching bearing plates to beams or girders shall be cleaned and given 2 coats of zinc rich paint having a minimum total coating thickness of 3 mils.

3.02 ELASTOMERIC PADS

A. Care shall be taken in fabricating pads and related metal parts so that effects detrimental to their proper performance, such as uneven bearing and excessive bulging, will not occur.

3.03 PLACEMENT OF BEARING PLATES AND PADS

A. Bearing areas shall be finished to a true level plane which shall not vary perceptibly from a straightedge placed in any direction across the area.

B. Bearing plates or pads shall be set level in exact position and shall have a uniform bearing over the entire area. Provision shall be made to keep plates or pads in the correct position during erection of beams or placement of concrete.

C. Elastomeric pads and other flexible bearing materials shall be placed directly on masonry surfaces finished to a roughness equivalent to that of a No. 36 to No. 46 grit. Pads, bearing areas, or bridge seats and metal bearing plates shall be thoroughly cleaned and free from oil, grease, and other foreign materials. Metal bearing plates or bottoms of prefabricated beams that are to bear on elastomeric pads shall be coated with epoxy and then surfaced with a No. 36 to No. 46 silicon carbide or aluminum oxide grit. Bearing areas shall be finished to equivalent roughness.

D. Metal bearing plates shall be bedded on seats as follows:

1. The seat bearing areas shall be thoroughly swabbed with approved paint, and three layers of duck, 12 to 15 ounce per square yard, shall be placed on it, each layer being thoroughly swabbed with paint on its top surface.

2. Superstructure shoes or pedestals shall be placed in position while paint is plastic. As an alternate to duct and paint, preformed fabric bedding material at least 1/8 inch in thickness may be used when called for on the Drawings or approved in writing by the Engineer.

3.04 PLACEMENT OF ANCHOR RODS

A. All necessary anchor rods and bolts (anchors) shall be accurately set either in the concrete as they are being placed, in formed holes, or in holes cored after the concrete has set. If set in the concrete, the rods and bolts shall be accurately positioned by means of templates and rigidly held in position while the concrete is being placed. Holes may be formed by inserting or casting in the fresh concrete oiled wooden plugs, metal pipe or plastic sleeves, or other approved devices, and withdrawing them after the concrete has partially set or left in place as indicated on the Drawing's or approved by the Engineer. Holes so formed shall be at least 3 inches in diameter or at least 2.5 times the diameter of the rod or bolt. If cored, holes shall be at least 2.5 times the diameter of the anchor used or as indicated on the Drawings. Equipment used for coring concrete shall have been approved by the Engineer. Impact tools will not be permitted. Reinforcing steel shall be placed to provide adequate space to core rod/bolt holes without cutting the reinforcing steel. For cored holes, anchor rods and bolts shall be adequately held in place at the centroid of the hole or as specified on the Drawings by using approved pre-fabricated equalizers designed to allow grout to penetrate and fill the hole completely and spaced as approved by the Engineer.

B. During freezing conditions, anchor holes shall be protected from water accumulations at all times.

C. Anchors which are to be placed in holes of sufficient and specified diameter after the concrete has set shall be bonded to the concrete with a non-shrink high-strength Portland cement grout in accordance with Section 03600 – Grout or shall be adhesive anchors in accordance with Section 05050 - Metal Fastening. The type anchoring system and grout shall be as indicated on the Drawings. The grout or adhesive shall completely fill the holes. Anchors shall be tested for sufficient pull-out capacity as indicated in applicable sections of the Specifications or as indicated on the Drawings.

D. Anchors that are not designed to project through bearing plates shall be checked for proper projection above the masonry bearing area immediately prior to placement of bearing plates and beams. Nuts on anchor rods at expansion ends shall be adjusted to permit free movement of the span.

E. Angles for anchor assemblies to be attached to sides of concrete beams shall not be installed until beams have received their full dead load and supporting falsework has been removed.

- END OF SECTION -

SECTION 07900

JOINT FILLERS, SEALANTS AND CAULKING

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Furnish labor, materials, equipment and appliances required for the complete execution of Work shown on the Drawings and specified herein.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 03250 - Concrete Accessories

B. Section 03290 - Joints in Concrete

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.

1. ASTM C-920 Elastomeric Joint Sealants

2. ASTM D-1056 Flexible Cellular Materials - Sponge or Expanded Rubber

3. SWRI Sealant and Caulking Guide Specification

1.04 SUBMITTALS

A. In accordance with the procedures and requirements set forth in Section 01300 – Submittals, submit the following:

1. Manufacturers literature and installation instructions.

2. Color samples of each type of sealant.

1.05 QUALITY ASSURANCE

A. Applicator shall be a company specializing in the installation of sealants with a minimum of five years experience.

1.06 DELIVERY, STORAGE AND HANDLING

A. Deliver materials in unopened labeled packages.

B. Store materials in location protected from freezing or damage
C. Reject and remove from the site materials within broken or damaged packaging.

PART 2 -- PRODUCTS

2.01 MATERIALS

A. Sealants

1. Type 1: Multi-component, non-sag, low-modulus polyurethane rubber sealant meeting ASTM C-920, Type M, Grade NS, Class 25, use NT, M, A, and O. Capable of withstanding 50% in extension or compression such as Sikaflex-2C NS/SL, Sika Corporation, or Sonolastic NP-2, Sonneborn, or DynaTrol II by Pecora Corporation.

2. Type 2: Single component polyurethane sealant meeting ASTM C-920, Type S, Grade NS, Class 25, Use NT, M, A, and O. Capable of withstanding 25% in extension or compression such as Sikaflex 1A by Sika Corporation, DynaTrol 1-XL by Pecora Corporation, or Sonolastic NP-1 by BASF Construction Chemicals.

3. Type 3: Single component, low-modulus moisture curing silicone meeting ASTM C-920, Type S, Grade NS, Class 25, Use NT, M, G, and A. Capable of withstanding 50% extension and compression. Pecora 890 by Pecora Corporation, Sonolastic Omni Seal by BASF Construction Chemicals.

4. Type 4: Nonsag, Multi Component, traffic grade polyurethane sealant meeting ASTM C920, Type 19, Grade NS, Class 25, use T, M, A, and O. DynaTread by Pecora Corporation, Sonolastic Ultra by BASF Construction Chemicals.

B. Primer: Non-staining primer recommended by sealant manufacturer for the substrates on this project.

C. Backer Rod: Closed cell foam, nonreactive with caulking materials, non-oily, and approved by the sealant manufacturer. Minimum density shall be 2.00 pounds per cubic foot. Use no asphalt or bitumen-impregnated fiber with sealants.

D. Joint Cleaner: Recommended by sealant or caulking compound manufacturer.

E. Bond breaker: Either polyethylene film or plastic tape as recommended by the sealant manufacturer.

F. Color: Where manufacturer's standard colors do not closely match materials being sealed, provide a custom color.

PART 3 -- EXECUTION

3.01 QUALITY CONTROL

A. In accordance with Section 01400, Quality Control.

B. Apply sealants and related items in temperatures and dry conditions recommended by the manufacturers.

B. Do not paint sealant, unless recommended by sealant and paint manufacturer.

3.02 PREPARATION

A. Protect finished surfaces adjoining by using masking tape or other suitable materials.

B. Clean and prime joints before starting any caulking or sealing work.

C. Thoroughly clean joints and spaces of mortar and other foreign materials. Cleaning agent shall be Xylol or similar non-contaminating solvent to remove any film from metal surfaces. Masonry or concrete surfaces shall be brushed or air jet cleaned.

D. Joint Requirements

1. All joints and spaces to be sealed in exterior work shall be less than 1/2 inch deep and not less than 1/4 inch wide. If joints in masonry are less than that specified herein, the mortar shall be cut out to the required width and depth. All joints and spaces to receive sealant shall be completely prepared and thoroughly dry before installation of sealant.

2. Unless otherwise specified, joints and spaces which are open to a depth of 1/2 inch or greater shall be solidly filled with back-up material to within 1/4 inch of the surface. Back-up material shall be packed tightly and made continuous throughout the length of the joints. Bond breaker shall be applied as required. If joints are less than 1/4 inch deep, the back-up material may be omitted, a bond breaker substituted and the joint completely filled with sealant. The back-up material shall not project beyond the 1/4 inch depth of the open space in any joint. The following width-to-depth ratio table shall be adhered to, unless otherwise recommended by manufacturer.

| | Sealant Depth | |
|---|---|---|
| Joint Width | Minimum | Maximum |
| ¼ inch | 1/4 inch | 1/4 inch |
| Over 1/4 inch to 1/2 inch | 1/4 inch | Equal to width |
| Over 1/2 inch to 1 inch | 1/2 inch | Equal to width |
| Over 1 inch to 2 inch | 1/2 inch | 1/2 of width |

3.03 APPLICATION

A. Exercise care before, during, and after installation so as not to damage any material by tearing or puncturing. All finished work shall be approved before covering with any other material or construction.

B. Apply sealant by an approved type of gun except where the use of a gun is not practicable, suitable hand tools shall be used. Avoid applying the compound to any surface outside of

the joints or spaces to be sealed. Mask areas where required to prevent overlapping of sealant.

C. All joints shall be waterproof and weathertight.

D. Point sealed joints to make a slightly concave joint, the edges of which are flush with the surrounding surfaces. Exposed joints in the interior side of the door and other frames shall be neatly pointed flush or to match adjacent jointing work.

E. Adjacent materials which have been soiled shall be cleaned immediately and the work left in neat and clean condition.

F. Comply with sealant manufacturer's written instructions except where more stringent requirements are shown or specified and except where manufacturer's technical representative directs otherwise.

3.04 ADJUSTMENT AND CLEANING

A. Remove misplaced sealant compounds promptly using methods and materials recommended by the manufacturer, as the work progresses.

3.05 SCHEDULE

**Schedule of Sealants**

| Application | Sealant | Color |
|---|---|---|
| Vertical and horizontal expansion and construction joints in concrete structures unless noted otherwise herein or on Drawings. | Type 1 | To closely match adjacent surfaces or mortar and as selected by the Owner. |
| Vertical and horizontal joints bordered on both sides by masonry, precast concrete, natural stone or other porous building material, unless noted otherwise herein or on Drawings. | Type 2 | To closely match adjacent surfaces or mortar and as selected by the Owner. |
| Vertical and horizontal joints bordered on both sides by painted metals, anodized aluminum, mill finished aluminum, PVC, glass or other non-porous building material. | Type 3 | To closely match adjacent surfaces and as selected by the Owner. |
| Submerged in liquids. See Note 1. | Type 1 | Manufacturer's standard |
| Horizontal Joints exposed to vehicular or pedestrian traffic. | Type 4 | To closely match adjacent surfaces. |
| Other joints indicated on the drawings or customarily sealed but not listed. | Type recommended by manufacturer | To closely match adjacent surfaces and as selected by the Owner. |

Note 1. Where sealant will be immersed in liquid chemicals verify compatibility prior to installation of sealant.

- END OF SECTION -

SECTION 09801

MIC COATING SYSTEM

PART 1 -- GENERAL

1.01 THE REQUIREMENTS

A. Furnish and install special coating systems in accordance with the Contract Documents.

B. MIC Coating System

1. Install Microbiologically Influenced Corrosion (MIC) coating system where shown on the drawings, specifically the Manholes and Pump Station Wet Well Structures. The coating system shall extend across the bottom of the structure, from the bottom of the walls and up to the underside of the top slab as shown on the Drawings. Repair any voids with spall repair material.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Division 3 - Concrete

B. Section 09900- Painting

1.03 REFERENCE SPECFICATIONS, CODES AND STANDARDS

A. Without limiting the generality of these Specifications the Work shall conform to the applicable requirements of the following documents:

| | | |
|---|---|---|
| 1. | SSPC-SP13/NACE No. 6 | Surface Preparation of Concrete |
| 2. | NACE | National Association of Corrosion Engineers |
| 3. | SSPC | The Society of Protective Coatings |
| 4. | ASTM | American Society of Testing and Materials |

1.04 SUBMITTALS

A. Shop Drawings including the following items shall be submitted in accordance with Section 01300.

1. Manufacturer's product data and material safety data sheets for each coating product provided. Include manufacturer's color chart for each product supplied.

2. Manufacturer's installation instructions and recommendations specific to environmental conditions, surface preparation, substrate conditions, and application procedures.

3. Complete shop drawings including location and details for all terminations and transitions.

4. Certifications:

    a. Furnish affidavits from the manufacturer certifying that materials furnished conform to the requirements specified.

    b. Certify concrete repair and coating products have been checked for compatibility.

    c. Certification from manufacturer stating the applicator and applicator's assigned personnel are certified and have received specific training for the application of the MIC coating system.

    d. Certificate from applicator stating the assigned personnel have received specific training for the application of the MIC coating system.

    e. Submit manufacturer's representative or independent inspector's NACE or SSPC certification.

5. Submit manufacturer's representative name, address and telephone number who will inspect work.

6. Provide list of at least 10 applications in high $H_2S$ environments in Southern or Mid-Atlantic States including contact names, address, phone numbers and date of installation for both the coating system and the applicator.

7. Field Data Records and Installation Reports.

8. Product Warranty.

9. Closeout Submittals:

    a. As-built drawings which include coating application limits, transitions, and terminations.

    b. Photos

    c. Quality assurance records, field data records and installation reports

    d. Certificate of Surface Preparation

    e. Test and evaluation reports including pull-off strength (adhesion) and spark testing.

f. Final Report

g. Final Certified Warranty

1.05 QUALIFICATIONS

A. Products shall be manufactured by company specializing in manufacturing the products specified in this section with a minimum of five continuous years of experience for performance in similar applications in wastewater treatment plants and wastewater collection systems.

B. The Contractor performing the work shall be fully qualified, experienced and equipped to complete this work expeditiously and in a satisfactory manner and shall be an approved installer of the coating system as certified and licensed by the manufacturer. The Contractor shall have successfully installed a minimum of 50,000 square feet of the proposed system and shall have a minimum of five (5) years service for applying the selected lining or coating system as documented by verifiable references. There shall be no exceptions to this experience requirement. The Contractor shall submit the following information to the Engineer for review and approval before any work is performed. The following information is required.

1. The number of years of experience in performing this type of specialized work and in installing the specified coating system.

2. Name of the manufacturer and supplier for this work and previous work listed below.

3. A list of municipal clients that the Contractor has performed this type of work including names, phone numbers, and square feet of material installed.

4. The Contractor shall submit a certified statement from the manufacturer that he/she is a certified and/or licensed installer of the coating.

1.06 QUALITY ASSURANCE

A. The supplier shall be responsible for the provisions of all test requirements specified in the referenced ASTM Standards as applicable. The supplier shall also bear the cost of all tests specified in Paragraph 3.05, Field Testing and Acceptance of MIC Coating System. In addition, all coating products to be installed under this Contract may be inspected at the plant for compliance with these specifications by an independent testing laboratory provided by the Owner. The Contractor shall require the manufacturer's cooperation in these inspections. The cost of plant inspection of all products and materials approved for this Contract shall be borne by the Owner.

B. Inspections of the coating products and materials may also be made by the Engineer or other representatives of the Owner after delivery. The products and materials shall be subject to rejection at any time on account of failure to meet any of the Specification requirements, even though samples may have been accepted as satisfactory at the place of manufacture. Materials rejected after delivery shall be marked for identification and shall be removed from the job at once.

1. Provide adequate time and access for inspections for the following major activities:

    a. Pre-surface preparation
    b. Monitoring of surface preparation
    c. Post-surface preparation
    d. Monitoring of repair and resurfacing product application
    e. Post repair and resurfacing products
    f. Monitoring of coating application
    g. Post application inspection and testing
    h. Corrective actions and final inspection

C. Pre-installation Meeting

1. At least two weeks prior to beginning work, the Contractor shall conduct a Pre-installation Meeting to discuss coating procedures and submittals. Attendees shall include the Coating Applicator, Owner, Engineer, Manufacturer's Technical Representative, Testing and Inspection Agencies (if applicable), Concrete Repair subcontractor (if applicable) and the Contractor. The minimum agenda includes:

    a. Environmental condition requirements
    b. Surface temperature requirements
    c. Surface pH requirements
    d. Surface preparation procedures
    e. Cleaning procedures
    f. Testing procedures to determine moisture content of concrete
    g. Proper procedures to fill substrate
    h. Application equipment
    i. Proper application of primer
    j. Proper application of coating system
    k. Proper termination and transition details
    l. Inspection of coating during and after application
    m. Testing of coating.
    n. Repair methods
    o. Documentation requirements
    p. Approval Procedures

D. Field Data Records

1. Maintain daily Quality Assurance Records including the following:

a. Date

b. Atmospheric Temperature and Humidity

c. Substrate pH

d. Substrate Temperature

e. Dew Point

f. Product Batch Numbers

g. Mixing Time for Each Part and the Combined Parts of a Coating System

h. Pot Life

i. Curing Time of Primer and Finish Layers

j. Holiday Test Results and Repair Data

k. Foreman or Supervisor's Signature

1.07 SERVICES OF MANUFACTURER'S REPRESENTATIVE

A. Provide the services of a qualified manufacturer's technical representative who shall adequately supervise the surface preparation and application of the coating and lining products. The manufacturer's representative shall be available to evaluate the coating at each step through the process and shall supervise the lining or coating application until the installer has shown through the proper surface preparation and application of the lining or coating that the system will be installed in accordance with all manufacturer recommendations.

B. Manufacturer's technical representative or authorized inspector shall be currently certified by SSPC.

C. A manufacturer's technical representative shall observe the application of the complete system a minimum of two days at the beginning of the application at each structure specified to receive MIC coating system. The manufacturer's technical representative shall provide guidance to ensure proper application of the system.

D. The manufacturer's technical representative shall submit to the Engineer a final report, at the completion of the work, identifying the products used, verifying and certifying that surfaces and lining systems were properly applied, free of pinholes, blisters and other blemishes that will compromise the coating performance and that the coating systems were proper for the exposure and surface. Discrepancies that are found during the final inspection shall be repaired and reinspected until system is completely satisfactory.

1.08 DELIVERY, STORAGE AND HANDLING

A. Care shall be taken in shipping, handling and placing to avoid damaging the products. Extra care may be necessary during cold weather construction. Any product or material damaged in shipment shall be replaced as directed by the Engineer.

B. Products shall be delivered to the site in clearly labeled containers and packaging. While stored, the products shall be adequately packaged and protected. Products shall be stored in a manner as recommended by manufacturer.

C. Any product showing deterioration, or which has been exposed to any other adverse storage condition that may have caused damage, even though no such damage can be seen, shall be marked as rejected and removed at once from the work.

1.09 WARRANTY

A. All lining and coatings installed shall be guaranteed by the Contractor for a period of two years from the date of final acceptance. During this period, all defects discovered in the coating, as determined by the Owner or Owner's Engineer shall be repaired or replaced in a satisfactory manner by the Contractor at no cost to the Owner.

B. The Contractor is responsible for properly preparing the structures for coating prior to the installation of the systems, including stopping all leaks, patching voids, protecting or removing and handling all mechanical equipment such as valves and valve assemblies and weirs, cleaning surfaces, removing rubble, etc.

## PART 2 – PRODUCTS

2.01 PRIMER

A. Primer shall be moisture tolerant, suitable for the environmental conditions, and compatible with the MIC coating. Primer shall be as recommended and preferably manufactured by the manufacturer of the MIC Coating System. If approved by manufacturer, MIC Coating System can be self-priming.

B. Primer shall be as recommended by the coating manufacturer to achieve a superior coating system performance. Manufacturer shall select primer based on substrate moisture, environmental conditions and humidity, substrate temperature, pH, and other properties.

2.02 MIC COATING SYSTEM

A. Provide MIC Coating System on surfaces indicated to receive MIC Coatings in this specification and on drawings. MIC Coating System is to be applied only by Factory Trained and Certified Applicators.

B. The MIC Coating shall be an epoxy mortar system such as Raven 405 as manufactured and applied by Raven Lining Systems. Additional approved systems include: Sherwin-Williams.

C. The MIC Coating shall be applied in two (2) coats of 40 to 50 mils each for a total DFT of 80 to 100 mils. In addition to MIC Coating, fill bugholes, depressions, and irregularities in surfaces with any dimension greater than 0.0625 inch with epoxy filler recommended by manufacturer and apply primer at 10 mils recommended by manufacturer to achieve superior performance.

D. MIC Coating System shall meet the following minimum characteristics:

1. Total Film Thickness of System including primers shall not be less than 100 mils (unless otherwise noted).

2. Chemical Resistance of 10% of sulfuric acid.

3. Water Vapor Permeance of 0.002 perms per ASTM E96, Method E.

4. Concrete Tensile Pull Strength 350 psi ASTM D4541.

5. Tensile Strength of 2,750 psi ASTM D412.

6. Abrasion Resistance, CS17 Wheel <120mg loss, ASTM D4060, 1000 gm load/1000 cycles.

7. Minimum Shore Hardness D50, ASTM D2240.

8. Resistant to negative water infiltration.

9. 100% solids epoxy mortar system containing aggregate and/or fiber reinforcement.

## PART 3 -- EXECUTION

### 3.01 PROTECTION OF IN-PLACE CONDITIONS

A. Equipment, vehicles, buildings, and other finished items shall be protected from damage and overspray. Sensitive equipment shall be wrapped in plastic and tape.

### 3.02 SURFACE PREPARATION

A. Surfaces to receive coating shall be clean and free of dirt, oil, grease, and other foreign materials.

B. Concrete and masonry surfaces shall cure for 28 days minimum prior to coating. Moisture content of concrete and masonry surfaces shall conform to manufacturer's recommended limits, and as listed in SSPC-SP13/NACE 6 Section 6 Acceptance Criteria Table 1. Surfaces shall be tested in accordance with ASTM D4263 – Plastic Sheet Test, ASTM F1869 – Calcium Chloride and ASTM F2170 – Relative Humidity Gauge as recommended by the manufacturer.

C. Test surfaces to ensure they are within requirements of the manufacturer. Do not begin coating work until moisture is within manufacturer’s recommended range. Any leaks shall be repaired as all surfaces shall be free of visible moisture and floating water.

D. Minimum surface preparation of concrete shall be per Section 09900, SSPC 13, and provide a surface profile as required by the coating manufacturer. Remove all laitance, weak concrete, dirt, and other contaminants. Remove all fins, protrusions, and similar imperfections to allow a uniform surface after surface preparation. Under no circumstance shall surface preparation be less than manufacturer’s recommendation to provide the best possible installation. Moisture

levels of concrete shall be tested and documented and within acceptable ranges prior to application of coating.

E. Bugholes, depressions, and irregularities in surfaces with any dimension greater than 0.0625 inch shall be filled with epoxy filler recommended by manufacturer.

F. Where the surface deterioration is less than or equal to 1/2 inch (as measured from the final finished surface to the prepared surface to be repaired) skim coats of epoxy modified cementitious mortar shall be applied to restore and smooth surface irregularities to the final finished surface. Epoxy modified mortar system shall be manufactured by same manufacturer of MIC Coating System.

G. Where the surface deterioration is greater than 1/2 inch the surface shall be repaired to final finished surface using Spall Repair Patching Material. Surface material shall be applied in strict accordance with manufacturer's printed instructions and recommendations. Materials shall be cured a minimum of 10-days or as recommended by the repair material manufacturer for the site conditions. Manufacturer of MIC Coating System shall confirm proposed spall repair patching material is compatible with MIC Coating System.

H. Where manufacturer requires additional surface preparation, to provide best possible installation, additional requirements shall be performed.

I. Provided written certification on the coating manufacturer’s letterhead, signed by an officer of the company that the surface preparation meets the requirements of the coating manufacturer.

3.03 PRIMER APPLICATION

A. Apply tolerant primer at 10 mils or as recommended by manufacturer to achieve superior performance. Test moisture and pH levels of concrete and document. Apply primer when surface is within acceptable ranges prior to application of primer.

3.04 MIC COATING APPLICATION

A. All methods, procedures of mixing, application and curing of the coating material shall be accomplished in strict accordance with manufacturer's printed instructions and recommendations.

B. Apply MIC Coating in a minimum of two coats in addition to primer and filler. Apply MIC coating in two (2) coats of 60 mils each for a total DFT of 120 mils, or in strict accordance with manufacturer’s printed instructions and recommendations.

C. Application shall be by certified and experienced personnel only. Application of coating systems shall take place when the temperature of the concrete is stable or falling to ensure a minimal amount of out gassing by concrete. Use dehumidification units, fans or other means to provide an adequate environment for application and cure when the environment is not adequate for application or cure.

D. Application shall produce at a minimum a totally bonded coating, corrosion proof, free of blisters, pinholes and any and all blemishes that may be precursors to failure. Promptly

correct or remove, and repair areas that fail visual inspection or testing. Recoat time between coats shall be documented and shall not exceed manufacturer's requirements. Where recoat times are exceeded the coating shall be prepared in strict accordance with manufacturer's recommendations including scarification to provide sufficient profile.

E. Follow manufacturer's recommendations for terminating coating into a chase and providing 1" radius inside corners, and easing outside corners. Provide a 1-1/2 inch cant cove along the floor/wall transition.

3.05 FIELD TESTING AND ACCEPTANCE OF MIC COATING

A. Field acceptance of the MIC coating system shall be based on the Engineer's evaluation of the appropriate installation of each coat per field inspections, on observation of the measurements of the wet film thickness, and on the observation of spark testing and adhesion testing conducted on the cured liner.

B. Pre-application testing shall be conducted by applying the MIC Coating at 20 mil thickness over a 5 square foot area where directed to demonstrate the coating application to the inspector(s).

C. During application of each layer of the MIC coating, the Contractor shall measure the thickness and uniformity of the coating by the use of a wet film thickness gage meeting the requirements of ASTM D4414. The wet film thickness shall be tested continuously for the Contractors own use. At least three such tests will be observed by the Engineer or Owner for each coat in each 500 square feet.

D. The MIC coating shall provide a continuous monolithic surfacing with uniform thickness throughout and be free of pinholes, slumps and drips.

E. All surfaces shall be inspected via high voltage spark testing when all coating work is complete and the coating is hard to the touch.

1. The structure environment shall be properly vented prior to testing to ensure hazardous conditions do not exist.

2. High voltage spark testing shall be performed in accordance with ASTM D4787. The spark testing equipment shall be initially set at 100 volts per 1 mil of applied film thickness of the coating and then adjusted as necessary per ASTM D 4787.

3. All detected holidays shall be marked and the area of the liner shall be repaired. The surface area around the coating shall first be abraded using an appropriate grit paper or other hand abrasion tool. After abrading and cleaning the area, the area shall be patched by hand application of the coating material. All repair procedures shall follow manufacturer's recommended procedures.

F. The pull-off strength (adhesion) of the liner shall be tested using any one of the five Test Methods (A, B, C, D or E) described in ASTM D-4541. The Contractor shall propose the method and equipment to be used in the tests. The liner adhesion shall be tested in one area for each structure or each 1000 square feet of coated area. At least three replicate pull-off tests shall be performed for each area. The Contractor shall also submit his proposed method

for reinstatement of the area of the coating affected by the test. Repair of test areas shall be made by the Contractor at no additional cost to the Owner.

G. There shall be no groundwater infiltration or other leakage through the structure walls after coating. If leakage is found, it shall be eliminated with an appropriate method as recommended by the coating manufacturer and approved by the Engineer at no additional cost to the Owner.

H. All pipe connections shall be open and clear.

I. There shall be no cracks, voids, pinholes, uncured spots, dry spots, lifts, delaminations or other type defects in the lining.

J. If any defective coating is discovered after it has been installed, it shall be repaired or replaced in a satisfactory manner within 72 hours and at no additional cost to the Owner. This requirement shall apply for the entire guarantee period.

- END OF SECTION -

SECTION 09900

PAINTING

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Furnish labor, materials, equipment and appliances required for complete execution of Work shown on Drawings and Specified herein.

B. Refer to 02732-Sanitary Sewer Force Mains Section 2.1 Part 6 for painting of above ground piping.

C. Section Includes:

1. Paint Materials

2. Shop Painting

3. Field Painting

a. Surface Preparation

b. Piping and Equipment Identification

c. Schedule of Colors

d. Work in Confined Spaces

e. OSHA Safety Colors

1.02 RELATED SECTIONS

A. Section 15030 - Piping and Equipment Identification Systems

1.03 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Without limiting the generality of these specifications, the Work shall conform to the applicable requirements of the following documents:

1. SSPC – The Society for Protective Coatings Standards

| | | |
|---|---|---|
| a. | SSPC-Vis 1 | Pictorial Surface Preparation Standards for Painting Steel Structures |
| b. | SSPC-SP2 | Hand Tool Cleaning |

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c. SSPC-SP3 Power Tool Cleaning

d. SSPC-SP5 White Metal Blast Cleaning

e. SSPC-SP6 Commercial Blast Cleaning

f. SSPC-SP10 Near-White Metal Blast

g. SSPC-SP13/NACE6 Surface Preparation of Concrete

2. NACE - National Association of Corrosion Engineers

3. ASTM D1737 - Test Method for Elongation of Attached Organic Coatings with Cylindrical Mandrel Apparatus

4. ASTM B117 - Method of Salt Spray (Fog) Testing

5. ASTM D4060 - Test Method for Abrasion Resistance of Organic Coating by the Taber Abraser

6. ASTM D3359 - Method for Measuring Adhesion by Tape Test

1.04 SUBMITTALS

A. In accordance with the procedures and requirements set forth in Section 01300 - Submittals, submit the following:

1. Manufacturer's literature and Material Safety Data Sheets for each product.

2. Painting schedule identifying surface preparation and paint systems proposed. Cross-reference with Tables 9-1 and 9-2. Provide the name of the paint manufacturer, and name, address, and telephone number of manufacturer's representative who will inspect the work. Submit schedule for approval as soon as possible following the Award of Contract, so approved schedule may be used to identify colors and specify shop paint systems for fabricated items.

1.05 SYSTEM DESCRIPTION

A. Work shall include surface preparation, paint application, inspection of painted surfaces and corrective action required, protection of adjacent surfaces, cleanup and appurtenant work required for the proper painting of all surfaces to be painted. Surfaces to be painted are designated within the Painting Schedule and may include new and existing piping, miscellaneous metals, equipment, buildings, exterior fiberglass, exposed electrical conduit and appurtenance.

B. Perform Work in strict accordance with manufacturer's published recommendations and instructions, unless the Engineer stipulates that deviations will be for the benefit of the project.

C. Paint surfaces which are customarily painted, whether indicated to be painted or not, with painting system applied to similar surfaces, areas and environments, and as approved by Engineer.

D. Piping and equipment shall receive color coding and identification. Equipment shall be the same color as the piping system.

1.06 QUALITY ASSURANCE

A. Painting operations shall be accomplished by skilled craftsman and licensed by the state to perform painting work.

B. Provide a letter indicating that the painting applicator has five years of experience, and 5 references which show previously successful application of the specified or comparable painting systems. Include the name, address, and the telephone number for the Owner of each installation for which the painting applicator provided services.

1.07 STORAGE AND DELIVERY

A. Bring materials to the job site in the original sealed and labeled containers.

B. Container label to include manufacturer's name, type of paint, brand name, lot number, brand code, coverage, surface preparation, drying time, cleanup requirements, color designation, and instructions for mixing and reducing.

C. Store paint materials at minimum ambient temperature of 45 degrees F (7 degrees C) and a maximum of 90 degrees F (32 degrees C), in ventilated area, and as required by manufacturer's instructions.

## PART 2 -- MATERIALS

2.01 GENERAL INFORMATION

A. The term "paint" is defined as both paints and coatings including emulsions, enamels, stains, varnishes, sealers, and other coatings whether organic or inorganic and whether used as prime, intermediate, or finish coats.

B. Purchase paint from an approved manufacturer. Manufacturer shall assign a representative to inspect application of their product both in the shop and field. The manufacturer's representative shall submit a report to the Engineer at the completion the Work identifying products used and verifying that surfaces were properly prepared, products were properly applied, and the paint systems were proper for the exposure and service.

C. Provide primers and intermediate coats produced by same manufacturer as finish coat. Use only thinners approved by paint manufacturer, and only within manufacturer's recommended limits.

D. Ensure compatibility of total paint system for each substrate. Test shop primed equipment delivered to the site for compatibility with final paint system. Provide an acceptable barrier coat or totally remove shop applied paint system when incompatible with system specified, and repaint with specified paint system.

E. Use painting materials suitable for the intended use and recommended by paint manufacturer for the intended use.

F. Require that personnel perform work in strict accordance with the latest requirements of OSHA Safety and Health Standards for construction. Meet or exceed requirements of regulatory agencies having jurisdiction and the manufacturer's published instructions and recommendations. Maintain a copy of all Material Safety Data Sheets at the job site of each product being used prior to commencement of work. Provide and require that personnel use protective and safety equipment in or about the project site. Provide respiratory devices, eye and face protection, ventilation, ear protection, illumination and other safety devices required to provide a safe work environment.

2.02 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Specifications, provide products from one of the following manufacturers:

1. Tnemec Company Inc.

2. Sherwin-Williams

PART 3 -- EXECUTION

3.01 SHOP PAINTING

A. Shop prime fabricated steel and equipment with at least one shop coat of prime paint compatible with finish paint system specified. Prepare surface to be shop painted in strict accordance with paint manufacturer's recommendations and as specified. Finish coats may be shop applied, if approved by the Engineer. Package, store and protect shop painted items until they are incorporated into Work. Repair painted surfaces damaged during handling, transporting, storage, or installation to provide a painting system equal to the original painting received at the shop.

B. Identify surface preparation and shop paints on Shop Drawings. Verify compatibility with field applied paints.

3.02 SURFACE PREPARATION

A. General

1. Surfaces to be painted shall be clean and dry, and free of dust, rust, scale, and foreign matter. No solvent cleaning, power or hand tool cleaning shall be permitted unless approved by the Engineer.

2. Protect or remove, during painting operations, hardware, accessories, machined surfaces, nameplates, lighting fixtures, and similar items not intended to be painted prior to cleaning and painting. Reposition items removed upon completion of painting operations.

3. Examine surfaces to be coated to determine that surfaces are suitable for specified surface preparation and painting. Report to Engineer surfaces found to be unsuitable in writing. Do not start surface preparation until unsuitable surfaces have been corrected. Starting surface preparation precludes subsequent claim that such surfaces were unsuitable for the specified surface preparation or painting.

4. Surface preparation shall be in accordance with specifications and manufacturer's recommendations. Provide additional surface preparation, and fill coats where manufacturer recommends additional surface preparation, in addition to requirements of specification.

5. Touch-up shop or field applied coatings damaged by surface preparation or any other activity, with the same shop or field applied coating; even to the extent of applying an entire coat when required to correct damage prior to application of the next coating. Touch-up coats are in addition to the specified applied systems, and not considered a field coat.

6. Protect motors and other equipment during blasting operation to ensure blasting material is not blown into motors or other equipment. Inspect motors and other equipment after blasting operations and certify that no damage occurred, or where damage occurred, the proper remedial action was taken.

7. Field paint shop painted equipment in compliance with Color Coding and as approved by Engineer.

B. Metal Surface Preparation

1. Conform to current The Society for Protective Coatings Standards (SSPC) Specifications for metal surface preparation. Use SSPC-Vis-1 pictorial standards or NACE visual standards TM-01-70 or TM-01-75 to determine cleanliness of abrasive blast cleaned steel.

2. Perform blast cleaning operations for metal when following conditions exist:

   a. Moisture is not present on the surface.

   b. Relative humidity is below 80%.

   c. Ambient and surface temperatures are 5°F or greater than the dew point temperature.

   d. Painting or drying of paint is not being performed in the area.

e. Equipment is in good operating condition.

f. Proper ventilation, illumination, and other safety procedures and equipment are being provided and followed.

3. Sandblast ferrous metals to be shop primed, or component mechanical equipment in accordance with SSPC-SP5, White Metal Blast.

4. Sandblast field prepared ferrous metals in accordance with SSPC-SP10, Near White Metal Blast, where metal is to be submerged, in a corrosive environment, or in severe service.

5. Sandblast field prepared ferrous metals in accordance with SSPC-SP6 Commercial Blast, where metal is to be used in mild or moderate service, or non-corrosive environment.

6. Clean nonferrous metals, copper, or galvanized metal surfaces in accordance to SSPC-SP1, Solvent Cleaning, or give one coat of metal passivator or metal conditioner compatible with the complete paint system.

7. Prime cleaned metals immediately after cleaning to prevent rusting.

8. Clean rusted metals down to bright metal by sandblasting and immediately field primed.

C. Concrete Surface Preparation

1. Cure concrete a minimum of 30 days before surface preparation, and painting begins.

2. Test concrete for moisture content using test method recommended by the paint manufacturer. Do not begin surface preparation, or painting until moisture content is acceptable to manufacturer.

3. Prepare concrete surfaces to receive coatings in accordance with SSPC-13 – Concrete Surface Preparation. Remove contaminants, open bugholes, surface voids, air pockets, and other subsurface irregularities. Do not expose underlying aggregate. Use dry, oil-free air for blasting operations. Surface texture after blasting shall be similar to that of medium grit sandpaper. Remove residual abrasives, dust, and loose particles by vacuuming or blowing with high pressure air.

4. Surface defects, such as hollow areas, bugholes, honeycombs, and voids shall be filled with polymeric filler compatible with painting system. Complete fill coats may be used in addition to specified painting system and as approved by the Engineer. Fins, form marks, and all protrusions or rough edges shall be removed.

5. Repair existing concrete surfaces which are deteriorated to the point that surface preparation exposes aggregate with fill coats or patching mortar as recommended by paint manufacturer and as directed by the Engineer.

6. Clean concrete of all dust, form oils, curing compounds, oil, tar, laitance, efflorescence, loose mortar, and other foreign materials before paints are applied.

D. Wood

1. Clean wood surfaces free of all foreign matter, with cracks and nail holes and other defects properly filled and smoothed. Remove sap and resin by scraping and wipe clean with rags dampened with mineral spirits.

2. Saturate end grain, cut wood, knots, and pitch pockets with an appropriate sealer before priming.

3. Prime and backprime wood trim before setting in place.

4. After prime coat has dried, fill nailholes, cracks, open joints, and other small holes with approved spackling putty. Lightly sand wood trim prior to applying second coat of paint.

E. Castings

1. Prepare castings for painting by applying a brush or a knife-applied filler. Fillers are not to be used to conceal cracks, gasholes, or excessive porosity.

2. Apply one coat of primer with a minimum thickness of 1.2 mils in addition to coats specified. Allow sufficient drying time before further handling.

F. Masonry

1. Cure for a minimum of 30 days prior to paint application.

2. Clean masonry surfaces free from all dust, dirt, oil, grease, loose mortar, chalky deposits, efflorescence, and other foreign materials.

3. Test masonry for moisture content. Use test method recommended by paint manufacturer. Do not begin painting until moisture content is acceptable to manufacturer.

G. Previously-Painted Surfaces

1. Totally remove existing paint when: surface is to be submerged in a severe environment, paint is less than 75% intact, brittle, eroded or has underfilm rusting.

2. Surfaces which are greater than 75% intact require removal of failed paints and then spot primed. Spot priming is in addition to coats specified. Sand surfaces of existing painted to feather surface so removed painted areas will not be noticed.

3. Remove surface contamination such as oil, grease, loose paint, mill scale, dirt, foreign matter, rust, mold, mildew, mortar, efflorescence, and sealers.

4. Clean and dull glossy surfaces prior to painting in accordance with the manufacturer's recommendations.

5. Check existing paints for compatibility with new paint system. If incompatible, totally remove existing paint system or apply a barrier coat recommended by the paint manufacturer. Remove existing paints of undetermined origin. Prepare a test patch of approximately 3 square feet over existing paint. Allow test patch to dry thoroughly and test for adhesion. If proper adhesion is not achieved remove existing paint and repaint.

3.03 APPLICATION OF PAINT

A. Apply paint by experienced painters with brushes or other applicators approved by the Engineer, and paint manufacturer.

B. Apply paint without runs, sags, thin spots, or unacceptable marks.

C. Apply at rate specified by the manufacturer to achieve at least the minimum dry mil thickness specified. Apply additional coats, if necessary, to obtain thickness.

D. Special attention shall be given to nuts, bolts, edges, angles, flanges, etc., where insufficient film thicknesses are likely. Stripe paint prior to applying prime coat. Stripe painting shall be in addition to coats specified.

E. Perform thinning in strict accordance with the manufacturer's instructions, and with the full knowledge and approval of the Engineer and paint manufacturer.

F. Allow paint to dry a minimum of twenty-four hours between application of any two coats of paint on a particular surface, unless shorter time periods are a requirement by the manufacturer. Longer drying times may be required for abnormal conditions as defined by the Engineer and paint manufacturer. Do not exceed manufacturer's recommended drying time between coats.

G. Suspend painting when any of the following conditions exist:

1. Rainy or excessively damp weather.

2. Relative humidity exceeds 85%.

3. General air temperature cannot be maintained at 50°F or above through the drying period, except on approval by the Engineer and paint manufacturer.

4. Relative humidity will exceed 85% or air temperature will drop below 40°F within 18 hours after application of paint.

5. Surface temperature of item is within 5 degrees of dewpoint.

6. Dew or moisture condensation are anticipated.

7. Surface temperature exceeds the manufacturer's recommendations.

3.04 INSPECTION

A. Each field coat of paint will be inspected and approved by the Engineer or his authorized representative before succeeding coat is applied. Tint successive coats so that no two coats for a given surface are exactly the same color. Tick-mark surfaces to receive black paint in white between coats.

B. Use magnetic dry film thickness gauges and wet fiber thickness gauges for quality control. Furnish magnetic dry film thickness gauge for use by the Engineer.

C. Coatings shall pass a holiday detector test.

D. Determination of Film Thickness: Randomly selected areas, each of at least 107.5 contiguous square feet, totaling at least 5% of the entire control area shall be tested. Within this area, at least 5 squares, each of 7.75 square inches, shall be randomly selected. Three readings shall be taken in each square, from which the mean film thickness shall be calculated. No more than 20 percent of the mean film thickness measurements shall be below the specified thickness. No single measurement shall be below 80 percent of the specified film thickness. Total dry film thickness greater than twice the specified film thickness shall not be acceptable. Areas where the measured dry film thickness exceeds twice that specified shall be completely redone unless otherwise approved by the Engineer. When measured dry film thickness is less than that specified additional coats shall be applied as required.

E. Holiday Testing: Holiday test painted ferrous metal surfaces which will be submerged in water or other liquids, or surfaces which are enclosed in a vapor space in such structures. Mark areas which contain holidays. Repair or repaint in accordance with paint manufacturer's printed instructions and retest.

1. Dry Film Thickness Exceeding 20 Mils: For surfaces having a total dry film thickness exceeding 20 mils: Pulse-type holiday detector such as Tinker & Rasor Model AP-W, D.E. Stearns Co. Model 14/20, shall be used. The unit shall be adjusted to operate at the voltage required to cause a spark jump across an air gap equal to twice the specified coating thickness.

2. Dry Film Thickness of 20 Mils or Less: For surfaces having a total dry film thickness of 20 mils or less: Tinker & Rasor Model M1 non-destructive type holiday detector, K-D Bird Dog, shall be used. The unit shall operate at less than 75-volts. For thicknesses between 10 and 20 mils, a non-sudsing type wetting agent, such as Kodak Photo-Flow, shall be added to the water prior to wetting the detector sponge.

F. Paint manufacturer or his representative shall provide their services as required by the Engineer. Services shall include, but not be limited to, inspecting existing paint,

determination of best means of surface preparation, inspection of completed work, and final inspection of painted work 11 months after the job is completed.

3.05 PROTECTION OF ADJACENT PAINT AND FINISHED SURFACES

A. Use covers, masking tape, other method when protection is necessary, or requested by Owner or Engineer. Remove unwanted paint carefully without damage to finished paint or surface. If damage does occur, repair the entire surface adjacent to and including the damaged area without visible lapmarks and without additional cost to the Owner.

B. Take all necessary precautions to contain dispersion of sandblasting debris and paint to the limits of the work. Take into account the effect of wind and other factors which may cause dispersion of the sandblasting debris and paint. Suspend painting operations when sanding debris or paint cannot be properly confined. Assume all responsibilities and cost associated with damage to adjacent structures, vehicles, or surfaces caused by the surface preparation and painting operations.

3.06 PIPING AND EQUIPMENT IDENTIFICATION

A. Piping and equipment identification shall be in accordance with Section 15030, Piping and Equipment Identification Systems.

3.07 SCHEDULE OF COLORS

A. Match colors indicated. Piping and equipment colors are indicated in Section 15030. Colors which are not indicated shall be selected from the manufacturer's full range of colors by the Engineer. No variation shall be made in colors without the Engineer's approval. Color names and numbers shall be identified according to the appropriate color chart issued by the manufacturer of the particular product in question.

3.08 WORK IN CONFINED SPACES

A. Provide and maintain safe working conditions for all employees. Supply fresh air continuously to confined spaces through the combined use of existing openings, forced-draft fans and temporary ducts to the outside, or direct air supply to individual workers. Exhaust paint fumes to the outside from the lowest level in the contained space. Provide explosion-proof electrical fans, if in contact with fumes. No smoking or open fires will be permitted in, or near, confined spaces where painting is being done. Follow OSHA, state and local regulations at all times.

3.09 OSHA SAFETY COLORS

A. Paint wall around wall-mounted breathing or fire apparatus with the appropriate safety red color; area not exceed 2-feet wide by 3-feet high, unless apparatus covers the area. Fire apparatus include fire hoses, extinguisher, and hydrants.

B. Paint hazardous areas and objects in accordance with OSHA regulations.

TABLE 9-1
PAINTING SCHEDULE

| SURFACE | APPLICATION | PAINTING SYSTEM & NO. OF COATS | PRODUCT REFERENCE (TABLE 9.2) | TOTAL MIN. DRY FILM THICKNESS (MILS) |
|---|---|---|---|---|
| Concrete and Masonry | | | | |
| Interior masonry and concrete walls and ceilings | All new structures | 1 coat sealer<br>2 coats acrylic epoxy | 101<br>116 | 75-85 sq.ft./gal.<br>4-6/coat |
| Submerged wastewater | Diversion structure | See Section 09801<br><br>Provide filler as required and recommended by manufacturer | See Section 09801 | |
| Metals<br>Interior and exterior nonsubmerged (gloss) | All mechanical equipment, piping, etc. | 1 coat epoxy polyamide primer<br><br>1 coat epoxy polyamide<br>1 coat aliphatic polyurethane | 104<br><br>102<br>115 | 4-6<br><br>4-6<br>3-5 |
| Interior insulated | | 1 coat acrylic latex | 103 | 4 |
| Submerged Wastewater | All metal piping, and mechanical equipment, etc. | 2 coats high solids epoxy | 119 | 8-10/coat |
| Steel doors, door frames, steel stairs, monorails, structural steel, misc. metals (steel) | | 1 tie coat (See Note 2)<br>1 coat epoxy polyamide<br>1 coat aliphatic polyurethane | 121<br>102<br>115 | 2.5-3.5<br>5-8<br>3-4 |
| Aluminum surfaces in contact with concrete | | 2 coats coal tar | 107 | 26 |
| PVC Piping | | 1 coat epoxy polyamide<br>1 coat aliphatic polyurethane | 102<br>115 | 5-8<br>3-4 |
| Other | | | | |
| Interior: Wood | All new structures | 2 coats acrylic latex matte or satin | 103 | 2-3/coat |

Footnotes:

1. Paint manufacturer shall ensure compatibility with chemicals being contained and provide a paint system that is compatible with chemical being stored. Floor surfaces shall be slip resistant.
2. Where structural steel, misc. metals, steel joist truss, etc are primed in the factory manufacturer shall verify compatibility of coating system with epoxy polyamide – where not compatible provide tie coat as recommended by paint manufacturer or totally remove coating.

SECTION 10440

SIGNS

PART 1 -- GENERAL

1.01 SECTION INCLUDES

A. Aluminum Signs

B. Sign Lettering

1.04 SUBMITTALS:

A. Layout proof of the Emergency Sign prior to delivery to the sign fabricator.

B. Layout proof of the Address Sign prior to delivery to the sign fabricator.

C. Indicate proposed location and mounting height of the signs.

PART 2 -- PRODUCTS

A. The signs shall be fabricated of 1/8" aluminum plate and fastened with aluminum or stainless steel ties.

B. Size and wording shall be as indicated on the drawings subject to modifications during submittal process. Facility number and street address supplied by Owner.

C. Lettering shall be block style.

D. Paint shall be enamel type with a white reflective background (front and back), black lettering, and black border.

PART 3 -- EXECUTION

3.01 INSTALLATION

A. Mount to the pump station gate(s) or fence as directed by Owner.

B. Install true and level and secure firmly to fencing.

- END OF SECTION -

SECTION 11130

SUBMERSIBLE NON-CLOG PUMPS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, install, test, and place in acceptable operation submersible non-clog pumps and all necessary accessories as specified herein at the locations shown on the Drawings and as specified herein. All pumps shall be supplied by the same manufacturer.

1.02 OPERATING CONDITIONS AND PERFORMANCE REQUIREMENTS

| **System Curve** | | | |
|---|---|---|---|
| Flow (gpm) | 1,000 | 4,000 | 7,000 |
| Total Dynamic Head (feet) | 65 | 88 | 135 |

| **PS 094 Pump No. 1** | | | |
|---|---|---|---|
| Number of Units | | 1 | |
| Design Capacity (gpm) | 400 | 1,000 | 1,600 |
| Total Dynamic Head (feet) | 107 | 85 | 66 |
| Maximum Brake Horsepower | 16.6 | 33.0 | 41.0 |
| Maximum Pump Speed (rpm) | | 1775 | |
| Temperature of Liquid Pumped | | Ambient | |
| Suction Condition | | Flooded | |
| Maximum Size of Solids (Spherical Diameter, Inches) | | 3.5 | |
| Minimum Discharge Diameter (In.) | | 6 | |

| **PS 094 Pumps No. 2 – No. 4** | | | |
|---|---|---|---|
| Number of Units | | 3 | |
| Design Capacity (gpm) | 1,000 | 3,000 | 6,000 |
| Total Dynamic Head (feet) | 145 | 96 | 53 |
| Maximum Brake Horsepower | 56.3 | 132.9 | 123.5 |
| Maximum Pump Speed (rpm) | | 1185 | |
| Temperature of Liquid Pumped | | Ambient | |
| Suction Condition | | Flooded | |
| Maximum Size of Solids (Spherical Diameter, Inches) | | 3.5 | |
| Minimum Discharge Diameter (In.) | | 10 | |

1.03 SUBMITTALS

A. The following items shall be submitted with the Shop Drawings in accordance with, or in addition to the submittal requirements specified in Section 01300, Submittals:

1. Performance Affidavit

a. By these affidavits, each manufacturer must certify to the Contractor and the Owner, jointly, that he has examined the Contract Documents and that the equipment, apparatus, or process he offers to furnish will meet in every way the performance requirements set forth or implied in the Contract Documents.

b. The Contractor must transmit to the Engineer three (3) original copies of the affidavit given him by the manufacturer or supplier along with the initial Shop Drawing submittals.

c. The Performance Affidavit must be signed by an officer of the basic corporation, partnership, or company manufacturing the equipment and witnessed by a notary public.

d. The Performance Affidavit shall have the following format:

Addressed to: (Contractor) and Berkeley County Water & Sanitation

Reference: Mount Holly Commerce Park Improvements Phase 1

Text: (Manufacturer's Name) has examined the Contract Documents and hereby state that the (Product) meets in every way the performance requirements set forth or implied in Section ___ of the Contract Documents.

Signature: Corporate Officers shall be Vice President, or higher. (Unless statement authorizing signature is attached.)

B. Submit Operation and Maintenance manuals in accordance with Section 01300, Submittals.

1.04 WARRANTY AND GUARANTEE

A. Warranty and Guarantee shall be as specified in Section 01700, Project Closeout.

PART 2 -- PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Each pump shall be a submersible, non-clog, centrifugal pump, as manufactured by ABS or Flygt, no other substitutions will be accepted.
B. Controller used for this project shall be the MultiTrode MultiSmart Model MSU3MP advanced microprocessor based on pump controller, no exception.

C. Level Probe must be Flygt LSU100 or Pulsar DBI no substitutions.

2.02 ELECTRICAL AND CONTROL REQUIREMENTS

A. The pump manufacturer shall provide the power and control cables between the pump and the local disconnect switch, junction box, or control panel (see Drawings) and shall be responsible for reviewing the electrical drawings as necessary to determine the required cable length. All pumps for the same pumping application shall be provided with the same length of cable. No splices shall be allowed unless specifically indicated on the Drawings. Cables shall be PVC or oil resistant cloroprene rubber jacketed type SPC cable suitable for submersible pump applications, shall be sized according to NEC and ICEA standards, and shall meet with MSHA approval. Stainless steel strain relief connectors shall be furnished for all cables.

B. Cable Entry Water Seal

1. The cable entry water seal design shall insure a watertight and submersible seal without specific torque requirements. The cable entry shall be comprised of a single cylindrical elastomer grommet, flanked by stainless steel washers all having a close tolerance fit against the cable outside diameter and the entry inside diameter and compressed by the entry body containing a strain relief function, separate from the function of sealing the cable. The assembly shall bear against a shoulder in the pump top. The cable entry junction chamber and motor shall be separated by a stator lead sealing gland or terminal board, which shall isolate gaining access through the pump top. The junction chamber containing the terminal board shall be sealed from the motor by an elastomer compression seal O-ring. Connection between the cable conductors and stator leads shall be made with threaded compressed type binding post permanently affixed to the terminal board and thus perfectly leak proof. Each pump shall be equipped with separate terminal board that totally isolates the incoming power supply from the pump motor.

C. Electrical Requirements

| | Pump No. 1 | Pumps No. 2-4 |
|---|---|---|
| | | |
| **Motors** | | |
| Rating | 460V, 3 ph, 60 Hz | 460V, 3 ph, 60 Hz |
| Horsepower | 40 | 150 |
| Speed, rpm | 1760 | 1200 |
| Insulation | Class F | Class F |
| Explosion Proof | Yes | Yes |
| Inverter Duty | Yes | No |
| Service Factor | 1.15 | 1.15 |
| Motor Winding Temperature Switches | Yes | Yes |
| RTDs | No | No |
| Cooling Jacket | No | No |

D. The pump motor shall be a squirrel-cage induction type, housed in a watertight chamber. The stator winding and stator leads shall be moisture resistant. The use of bolts, pins, or other fastening devices requiring penetration of the stator housing shall not be allowed.

E. The motor shall be guaranteed for continuous unsubmerged duty, capable of sustaining a minimum of ten (10) starts per hour without overheating.

F. The motor shall be provided with pre-lubricated radial and thrust bearings which are designed to carry the entire load which may be imposed upon it under all operating conditions.

G. Moisture detector probes shall be provided in the oil-seal chamber. The pump manufacturer shall provide a moisture detection relay compatible with the probes. The relay shall be installed in the pump station control panel.

2.03 PUMP STATION CONTROL PANEL

A. Control panel shall be provided in a NEMA 4X, 304 or 316 stainless steel powder coated white, UL-508D listed, free-standing enclosure. All components of the control panel shall be NEMA rated and U.L. listed or recognized. IEC rated devices are not acceptable. Short circuit ratings for all equipment located within the control panel shall be 42kAIC rms, minimum. All controls, auxiliary contacts, relays, panels, transformers, motor starters, overload alarms, and other ancillary control panel equipment shall be provided. Control panel shall meet the applicable requirements of Division 16, Division 17, Specification 16902, and the elementary control schematics on the Contract Drawings. The control panel shall include, but not be limited to, the following:

1. A single, main circuit breaker, operable from outside the control panel. Main circuit breaker shall also be provided with a pad-lockable disconnecting means. Control panel shall only require a single, 480VAC, 3-phase power supply. Ratings for the main circuit breaker shall be as indicated on the Drawings.

2. Branch circuit breakers shall be provided for each of four (4) motor starters, one (1) control power transformer, one (1) hvac unit, and one (1) combination power unit, minimum. Branch circuit breaker ratings shall be as indicated on the Drawings.

3. One (1) variable frequency drive shall be provided as specified in Section 16495.

4. Three (3) reduced voltage solid state starters shall be provided as specified in Section 16481.

5. Control power shall be 120VAC from an integral control power transformer(s) via branch circuit breaker(s).

6. Pump controller and associated pump control equipment shall be provided as specified herein.

7. SCADA radio shall be provided as specified herein.

8. One (1) air conditioning unit shall be provided for the panel. Unit to be mounted to the side of the control panel and adequately sized to operate all equipment within control panel. Air conditioner to be in a NEMA 4X, 304 stainless steel enclosure.

9. Intrinsically safe barriers, as required.

10. A 12VDC power supply shall be provided inside the control panel for the SCADA Radio system. The system shall accept 120VAC input and consist of a DC power supply/charger, and battery.

    a. The 12VDC power supply/charger shall be 55W, minimum, with automatic reset for overcurrents. Output current shall be 0-10A; +/- 0.5% load regulation; +/-1% output voltage with 100mV pk-pk ripple. The charger shall be integral with the power supply.

    b. The 12VDC rechargeable battery shall be SLA, 12Ah, with hut and bolt or spade lug terminations.

11. All other items indicated on the Standard Pump Station Control Panel schematic drawings shall be provided to create a complete and operable system, even if items are not specifically indicated herein.

B. Control panel shall report alarms remotely via the SCADA system. Alarms shall be reported for any of the following reasons:

1. Multitrode Probe indicates high water level in wet well.

2. Moisture detection system indicates moisture in the oil chamber between the motor seals.

3. The motor winding temperature switches indicate high motor temperature caused by improper motor cooling or motor overload.

4. Overload protective devices in motor controls circuit indicate motor overload.

5. Electrical failure detected by the power failure control relay, or by the phase monitor.

6. RVSS failure.

7. VFD failure.

8. Motor branch circuit breaker disconnecting device left in the “off” position.

9. Other alarm events as shown on the pump control panel drawings.

C. Variable Frequency Drives (VFD)

1. The VFD shall be provided by the Pump Station Control Panel supplier, in accordance with Specification Section 16495 – Variable Frequency Drives.

D. Reduced Voltage Solid State Starters (RVSS)

1. The RVSS shall be provided by the Pump Station Control Panel supplier, in accordance with Specification Section 16481 – Individual Motor Controllers.

E. SCADA Communication Equipment

1. All SCADA communication equipment indicated within this section shall be provided by the pump control panel manufacturer.

3. The SCADA radio shall be CAL AMP Viper SC400 or as required by BCWS.

4. The surge suppressor shall be a Polyphaser bulkhead fitting.

F. Pump Controller and associated pump control equipment

1. Pump controller and associated equipment indicated within this section shall be provided by the Multitrode control equipment representative, Mr. Peter Carlson - Xylem, (704) 916-2607. No substitutions are permitted.

2. Pump controller shall be MultiTrode MultiSmart Model MSU3MP advanced microprocessor based pump controller with DNP3 Communication Protocol. No substitutions are permitted.

3. Pump controller shall be equipped with the following:

a. All components shall have the same minor software version number for system compatibility.

b. All interfacing cables to other equipment within control panel.

4. Level Controller shall be MultiTrode MSU3MP with included Motor Protection Monitoring Module, RTU, Flow Monitoring Function, and DNP3 Communication Protocol.

5. Level Probe shall be MultiTrode or MPE, 10 12inch segments, 3 meter

(approximately 10ft) conductive sensing probe. VFD stations will require an ultrasonic level sensing unit for speed control. Flygt LSU1000 or Pulsar DBI no substitutions. The probe will be installed as a back up.

6. Intrinsically Safe Barrier: MultiTrode Model MTISB-10 or MPE ISB10.

6. I/O Extension Module shall be Adams Model 6051.

7. The pump controller shall be used to provide advanced motor protection and data analysis of the system performance as well as integration with the SCADA equipment, as specified herein.

8. Transient Voltage Surge Suppressor (TVSS) or surge protective device shall be provided, prewired inside the enclosure. The UL 1449, 2nd Ed., surge protective device (SPD) shall provide 4-mode, line-voltage surge protection for the control panel incoming power supply. The SPD shall have a minimum surge rating of 200kA/phase, with each phase having its own status indicator.

9. Surge current modes are Line to Neutral, Line to ground, Neutral to Ground, and Line to Line, and each mode shall have a minimum of 100kA/phase protection. The TVSS shall be provided with a line-side, manual disconnecting switch inside the panel to simultaneously disconnect all ungrounded conductors for maintenance. Lead lengths shall be as short as possible.

G. Functional Control Description

1. Process Overview

a. Three (3) submersible (“large”) pumps shall be provided under Division 11 in the Pump Station wet well as shown on Drawings. These pumps shall be provided with a RVSS reduced voltage soft start (RVSS) starter in the Pump Station Control Panel (PSCP).

b. One (1) submersible (“small”) pump shall be provided under Division 11 in the Pump Station wet well as shown on the Drawings. The pump shall be provided with a variable frequency drive (VFD) starter in the PSCP.

c. Each pump shall be controlled locally via either the VFD or RVSS in MANUAL control mode or via the pump controller in AUTOMATIC control mode.

2. Control Equipment

a. A VFD shall be provided in the PSCP under Division 11 for the small pump. Reference Division 16 for VFD details. The motor controls shall include the following:

i. HAND-OFF-AUTO (H-O-A) selector switch
ii. START/STOP pushbuttons
iii. POWER ON indicating light

iv. RUN indicating light
v. MOTOR WINDING OVERTEMP indication light
vi. MOISTURE DETECTION indication light
vii. VFD FAULT indicating light
viii. PHASE MONITOR FAULT indicating light
ix. HIM Keypad (speed control and speed indication)
x. RESET pushbutton
xi. Elapsed Run Time meter

b. A RVSS shall be provided under Division 11 for each of the three (3) large pumps. Reference Division 16 for RVSS details. The motor controls shall include the following:

a. HAND-OFF-AUTO (H-O-A) selector switch
b. START/STOP pushbuttons
c. POWER ON indicating light
d. RUN indicating light
e. MOTOR WINDING OVERTEMP indication light
f. MOISTURE DETECTION indication light
g. RVSS FAULT indicating light
h. PHASE MONITOR FAULT indicating light
i. HIM Keypad
j. RESET pushbutton
k. Elapsed Run Time meter

c. One (1) Multitrode Multismart Pump Controller and expansion chassis shall be provided under Division 11 and as shown on the Drawings. Controller shall be programmed as indicated herein and in the most current BCWS Pump Control Systems Specification.

d. One (1) ultrasonic level sensor and one (1) Multitrode Level Probe shall be provided under Division 11 to continuously monitor wet well level of the pump station as located as shown on the Contract Drawings. Pressure transducer shall be programmed as indicated herein and in the most current BCWS Pump Control Systems Specification.

e. One (1) magnetic flow meter shall be provided under Division 17 to measure flow discharged from the pump station as shown on the Drawings. The flow shall be relayed to the SCADA system via the Multismart Pump Controller.

3. Control Operations

a. When the H-O-A switch for the small pump is in HAND, the small pump shall be started/stopped using the START/STOP pushbuttons at the PSCP and the speed shall be set on the VFD keypad. When the H-O-A switch is in OFF, the pump shall not run under any condition. When the H-O-A switch is in AUTO, the corresponding pump shall be controlled by the pump controller as described below.

b. When the H-O-A switch for a large pump is in HAND, the large pump shall be started/stopped using the START/STOP pushbuttons at the PSCP.

When the H-O-A switch is in OFF, the pump shall not run under any condition. When the H-O-A switch is in AUTO, the corresponding pump shall be controlled by the pump controller as described below.

c. The four (4) pumps shall operate in a step program consisting of two (2) steps. The one (1) small pump shall only reside in Step 1 and shall operate under normal operating conditions. The three (3) large pumps shall reside in Step 2 and shall operate in a lead/lag 1/lag 2 configuration. The intent is for two (2) large pumps to be utilized during peak flow conditions. Step 1 shall always lead Step 2. The step program shall transition between the two steps based on wet well levels as follows:

| **STEP 1 OPERATION** | | |
|---|---|---|
| **Wet Well Level** | **Action** | **Elevation** |
| High Level | High Level Alarm | 10.00 |
| Transition Level | Transition to Step 2 * | 7.00 |
| Start Level | Start Small Pump | 6.00 |
| Stop Level | Stop Small Pump | 2.00 |
| Low Level | Low Level Alarm | 1.00 |

* Shut down Step 1 pump after receiving Step 2 lead pump run confirmation.

| **STEP 2 OPERATION** | | |
|---|---|---|
| **Wet Well Level** | **Action** | **Elevation** |
| High Level | High Level Alarm | 10.00 |
| 3rd Pump Start Level | Start Lag 2 Pump | 9.00 |
| 2nd Pump Start Level | Start Lag 1 Pump | 8.00 |
| 1st Pump Start Level | Start Lead Pump | 7.00 |
| Stop Level | Stop All Pumps | 2.00 |
| Low Level | Low Level Alarm | 1.00 |

a. The small pump shall be provided with speed clamps. These speed clamps shall be adjusted to accommodate field conditions, but shall be initially set according to the following table:

| **Number of Pumps Running** | **Minimum Pump Speed (rpm)** | **Maximum Pump Speed (rpm)** |
|---|---|---|
| 1 small | 1420 | 1775 |

b. In Step 2, if 3 large pumps are required for operation, an alarm shall be sent to SCADA to notify the operator that the 3rd pump has started.

4. Pump Sequence and Rotation

a. In Step 1, the small pump shall operate continuously under normal operating conditions. If the small pump is not available for automatic control, the step program shall automatically proceed to Step 2.

b. In Step 2, the three (3) large pumps shall operate in a lead/lag 1/lag 2 configuration as follows:

i. The operator shall select either manual or automatic pump lead-lag rotation at the PSCP. In manual mode, the operator shall start/stop pumps manually at the PSCP. In auto mode, the pumps shall be started and stopped based on number of starts by starting the pump with the least number of starts each time a pump is called to start.

ii. If the process has not caused pumps to rotate in either mode, pumps shall rotate every 24 hours (operator adjustable set point 1-48 hours or never).

- In auto rotation mode, the sequence shall be reordered based on number of start values as described above. The pump with the lowest number of starts shall become the lead pump.

- If a pump is still required to be running after the sequence is reordered, the pump shall run continuously and shall not be called to stop during the reordering of the rotation sequence. For example, if two pumps are currently running when the sequence is reordered and the current lead pump becomes the new lag1, that pump shall not be stopped and started in rapid succession.

c. If a pump called to start fails to start after a hardcoded time delay, the next lag pump (Step 2) shall be started. If a pump in operation fails, the standby next lag pump (Step 2) shall be started after the initial start delay. The failed pump shall be moved to the end of the pump sequence.

5. Pump Station Cleaning Cycle

a. The number of large pumps used for the cleaning cycle shall be adjustable from the PSCP from 1-3 pumps. Designation of which large pumps to be used shall also be input at the PSCP. Any of the large pumps may be selected for the cleaning cycle. The pump controller shall alarm the PSCP if a pump is selected that is not available for automatic control by sounding an audible alarm and flashing “large pump selected is not in automatic mode”. A cleaning cycle will begin as long as at least one (1) large pump is available. An alarm shall be annunciated if a cleaning cycle is called for and one (1) large pump is not available by an audible alarm and indicating the following message on the PSCP “no large pump is available”.

b. The number of cleaning cycles in a seven (7) day period shall be adjustable (0-42) using the PSCP (initially set at 7). If more than one (1) cleaning cycle has been chosen each cleaning cycle shall be spaced equally over a seven (7) day period. The time of day for the first cycle to begin shall be adjustable from the PSCP with an initial time of 8:00 PM. The operator shall have the ability to initiate a cleaning cycle at any time using the PSCP and the pump controller will complete the cycle as described herein and then revert back to the frequency control previously defined.

c. When a cleaning cycle begins, all pumps are shut down. The wet well is allowed to fill until it reaches an elevation of 46.58. When the wet well reaches 46.58, one (1) large pump will startup and run at full speed. The large pump will operate until the water level in the wet well reaches 42.58 and the pump will stop and the cleaning cycle is complete. The pump station should now revert back to normal operations.

6. Pumps that are out of service, in manual (or remote-manual) control, or failed shall not be considered for automatic control.

7. After restoration of power following a power failure, the pump controller shall automatically restart pumps to the operating speed effective before the power failure. The timing of restart shall be adjustable by a user-adjustable time delay (0-15 minutes, initially set at 5 minutes).

8. An alarm shall be generated at the operator workstation to notify the operator if a pump starts more than five times in one hour.

9. Continuous wet well level shall be displayed at the PSCP.

H. EFFLUENT FLOW MEASUREMENT (PRIMARY)

1. Effluent flow from the pump station shall be measured by the new magnetic flow meter.

2. Control Operations

a. 4-20 mA signal outputs from the magnetic flow meter shall be connected to the pump controller.

b. The pump controller shall record and totalize the flows, then display both the instant and totalized flows at the PSCP.

I. EFFLUENT FLOW MEASUREMENT (SECONDARY)

1. Effluent flow from the pump station shall be calculated utilizing the Multitrode Multismart pump controller and the Flygt LS1000 or Pulsar DBI.

2. Control Operations

a. Signal outputs from the ultrasonic transducer shall be connected to the pump controller. Pulse counter will also be connected.

b. The pump controller shall record and totalize the flows, then display them at the PSCP.

J. SCADA Communication Equipment

1. All SCADA communication equipment located outside of the control panel shall be provided by the Contractor for installation in the field. This includes, but is not limited to, antenna, wood antenna pole, feed-line coaxial cable, conduit,

supporting straps, cable bonding/grounding kit, etc. Approximate locations of equipment are shown on the Drawings. Coordinate exact location with Owner prior to installation.

K. Enclosure

1. Enclosure shall be NEMA 4X, 304 stainless steel powder coated white with subpanel and interior swing open, dead front door. Enclosure shall be equipped with a 3-point, 90 degree turn, pad-lockable latch kit and a hinged interior door for mounting of controller displays, keypads, labels, and other required components.

2. Control components within the control panel shall be separated from power components based on the most recent edition of IEEE 518-1982.

2. Control panel shall be free-standing and secured firmly to the concrete equipment pad. Accessory feet kits shall be provided with adequate clearance to install conduit stub-ups and their associated sealing fittings, hardware, and hubs, from below.

3. Enclosure shall be sized to meet project requirements. Ensure adequate space is required for all wiring, and that proper space it provided for adequate air flow within the enclosure.

4. Provide a fully gasketed, dead-front enclosure with 3-point, quarter-turn latching, lockable door handle with concealed hinge. Hinges shall be completely rust-free under all circumstances. Enclosures, hinges, or hardware that rusts, including “surface” rust where pitting is evident, shall cause the entire panel to be replaced and any and all associated repair work and materials shall be at the Contractor’s expense and at no additional cost to BCWS.

## PART 3 -- EXECUTION

### 3.01 MANUFACTURER’S FIELD SERVICES

A. The services of a qualified manufacturer's technical representative shall be provided in accordance with this Section. For each series of pumps, field services shall include the following site visits:

| Service | Number of Trips | Number of Days/Trip |
|---|---|---|
| Installation and Testing | 1 | 1 |
| Startup and Training | 1 | 1 |
| Services after Startup | 1 | 1 |

### 3.02 SHOP TESTING

A. Shop testing shall be in accordance with the following additional requirements:

1. Impeller, motor rating and electrical connections shall be checked.

2. A motor and cable insulation test for moisture content or defective insulation shall be made.

3. During this test, shop testing should be completed to demonstrate compliance with the specified performance for flow, head, and horsepower.

3.03 FIELD TESTING

A. Final acceptance tests shall demonstrate the following:

1. The pumps have been properly installed and are in proper alignment.

2. The pumps operate without overheating or overloading of any parts and without objectionable vibration. Vibration shall be within the Hydraulic Institute limits, or manufacturer's limits if more stringent.

3. The pumps can meet the specified operating conditions. All pumps shall be checked at maximum speed for a minimum of four points on the pump curve for capacity, head, and amperage. The rated motor nameplate current shall not be exceeded at any point. Pumps with drive motors rated at less than five horsepower shall only be tested for overcurrent when overheating or other malfunction becomes evident in general testing.

- END OF SECTION -

SECTION 11315

YARD HYDRANTS

PART 1 -- GENERAL

1.01 SECTION INCLUDES

A. Freezeless Yard Hydrant

B. Concrete Support Base

1.02 SUBMITTALS:

A. Product fact sheet.

B. Indicate proposed location and installation details.

PART 2 -- PRODUCTS

A. The proposed hydrant shall be an Iowa Yard Hydrant, Model Y1, or equal.

B. Inlet size shall be 1” NPT, female.

C. Casing shall be 1 1/4” galvanized steel pipe.

PART 3 -- EXECUTION

3.01 INSTALLATION

A. Installation shall be as indicated on drawings.

B. Install true and level and connect to water supply system.

C. Relocate backflow prevention device.

- END OF SECTION -

SECTION 14605

MONORAIL SYSTEMS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, install and make fully operational the electric monorail system(s) which shall be complete with all necessary accessories, in compliance with the Specifications and as shown on the Drawings.

1. These Specifications shall be considered as minimum requirements. The Contractor shall add such additional features as are necessary for a satisfactory and complete operation.

2. All materials supplied under this Specification shall comply in all respects with the provisions of the Occupational Safety and Health Act of 1970, including all standards promulgated under the authority of such Act, and shall also meet all applicable industrial codes in the State in which the equipment is installed.

3. All parts furnished shall be amply designed and constructed for the maximum stresses occurring during fabrication, erection and continuous operation. All materials specified herein shall be designed for a Class A service in accordance with the Crane Manufacturer's Association of America.

B. It shall be the Contractor's responsibility to ensure that the monorails furnished shall be compatible and have the necessary clearances with the hoisting equipment for normal operation.

1. If the Contractor elects to utilize the monorail in any way during the erection of buildings and installation of equipment, he shall notify the Owner in writing and shall provide for an inspection by the monorail manufacturer and take any steps necessary to return the material to "as new" condition. He shall also obtain recertification by the manufacturer and reinstate all warranties and guarantees.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 01300 – Submittals

B. Section 11000 – Equipment General Provisions

C. Section 14620 – Trolley Hoists

1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Without limiting the generality of other requirements of the Specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced Specifications, codes and standards refer to the most current issue available at the time of Bid.

1. CMAA - Crane Manufacturers Association of America.

2. AISC – "Manual of Steel Construction"

3. ASTM A48 - Standard Specifications for Gray Iron Castings

4. ANSI B30.11 Safety Code for Underhung Cranes and Monorail Systems

5. ANSI B30.16 Safety Code for Overhead Hoists

1.04 SUBMITTALS

A. The Contractor shall submit Shop Drawings, Performance Affidavit, Operation and Maintenance Instructions and other information as specified in accordance with Section 01300, Submittals and Section 11000, Equipment General Provisions. Additional required information shall include the total weight of the material. Shop Drawings shall also include complete erection, installation, and adjustment instructions and recommendations.

1.05 QUALITY ASSURANCE

A. The materials covered by these Specifications are intended to be standard, of proven reliability and as manufactured by reputable manufacturers having experience in the production of such materials. The materials furnished shall be designed, constructed, and installed in accordance with the best practices and methods and shall provide satisfactorily operation when installed as shown on the Drawings and per manufacturers recommendations.

B. The warrantee shall be per Section 01300.

1.06 CONTRACTOR'S RESPONSIBILITIES

A. The manufacturer and ultimately the Contractor shall be totally responsible for structural design of the monorail system(s) proposed. The Contractor shall submit certification that the system(s) have been designed to resist all loads implied herein and loadings stipulated in the South Carolina Building Code. The Certification shall also state that the design has been performed and sealed by a registered Professional Engineer in the State of South Carolina.

B. The Contractor shall provide the services of a qualified manufacturer's technical representative who shall adequately supervise the installation and testing of all equipment furnished under this Contract and instruct the Owner's operating personnel in its maintenance and operation as outlined in Division 1. The services of the manufacturer's representative shall be provided for a period of not less than two (2) days as follows:

1. At least one trip of one (1) day to supervise and approve the installation of the equipment.

2. One trip of one (1) day after acceptance of the equipment to supervise initial start-up and operation and instruct the Owner's personnel in proper operation and maintenance of the equipment.

C. Any additional time required to achieve successful installation and operation shall be at the expense of the Contractor. The manufacturer's representative shall sign in and out at the office of the Engineer's Resident Project Representative on each day he is at the project.

## PART 2 -- PRODUCTS

### 2.01 MONORAIL

A. Unless otherwise indicated on the Drawings, monorail shall be patented track consisting of a top flange, web and hardened 3.25" or 3.33" bottom operation flange. All rails shall be furnished with splices and end stops and shall be designed for spans, thermal expansion and contraction and turning radii as shown on the Drawings. Unless otherwise shown on the Drawings provisions shall be made for connection of monorail suspension system to support locations designated on Drawings. The suspension system shall provide support and bracing of all live, dead, and impact loads. Monorail shall be manufactured by Louden division of ACCO, TC/American Monorail, Cleveland Tramrail division of Gorbel, Tram Beam, or equal. Rated capacity of monorail shall be painted with stencil on both the hoist and the monorail beam.

B. The monorail system(s) shall be designed for lifting and moving parts of process equipment during servicing and/or replacement in the locations and conditions of service as specified in the Hoist Schedule located at the end of Section 14620 - Trolley Hoists.

### 2.02 ELECTRICAL SYSTEM

A. Electrical equipment and wiring shall comply with the latest National Electric Code.

B. Electrical power wiring and connection to the electrical system integral to the equipment shall be provided under Division 16. All other power wiring associated with and integral to the hoist systems shall be furnished and installed under Division 16.

C. A track supported festoon system shall be supplied and shall include trolleys with tandem wheels of a corrosion resistant material which shall provide suitable service with the track that is used. The trolleys shall have saddles for supporting the cables in equal loops not exceeding 9'-0" of cable per loop. The track shall be stainless steel and supported at spans not exceeding 6'-0". The track shall be adequately supported with horizontal arms spanning to the festoon tow bar. The equipment manufacturer shall be fully responsible for the design and suitability of the festoon system.

PART 3 -- EXECUTION

3.01 INSTALLATION

A. Monorail and electrification shall be installed in accordance with Section 05120 - Structural Steel, Division 16, and manufacturer's instructions and recommendations.

B. Monorail and electrification installation shall be as approved by the manufacturer.

3.02 FIELD TESTS

A. Field tests shall be conducted in accordance with manufacturer's instructions and recommendations. Prior to initial use, monorail shall be proof-tested at 125% of rated load in accordance with all OSHA requirements. Certification shall be submitted in accordance with Section 01300 - Submittals.

3.03 PAINTING

A. All equipment shall have manufacturer's standard finishes. Field painting shall be as specified in Section 09900, Painting.

- END OF SECTION -

SECTION 14620

TROLLEY HOISTS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, install and make fully operational the trolley hoist(s), which shall be complete with all necessary accessories, in compliance with the Specifications and as shown on the Drawings.

1. These Specifications shall be considered as minimum requirements. The Contractor shall add such additional features as are necessary for satisfactory operation of the specified equipment.

2. All equipment supplied under this Specification shall comply in all respects with the provisions of the Occupational Safety and Health Act of 1970, including all standards promulgated under the authority of such Act, and shall also meet all applicable industrial codes in the State of South Carolina.

3. All parts of the mechanism furnished shall be amply designed and constructed for the maximum stresses occurring during fabrication, erection and continuous operation. All equipment specified herein shall be designed for a Class A service in accordance with the Crane Manufacturer's Association of America.

B. It shall be the Contractor's responsibility to ensure that the hoisting equipment furnished shall be compatible and have the necessary operating clearances with the monorail beam(s), or bridge crane(s) specified or shown on the Drawings.

1. If the Contractor elects to utilize the hoisting equipment in any way during the erection of buildings and installation of equipment, he shall notify the Owner in writing and shall provide for an inspection by the hoisting equipment manufacturer and take any steps necessary to return the equipment to "as new" condition. He shall also obtain recertification by the manufacturer and reinstate all warranties and guarantees.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 01300 – Submittals

B. Section 11000 – Equipment General Provisions

C. Section 14605 – Monorail Systems

1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Without limiting the generality of other requirements of the Specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced Specifications, codes and standards refer to the most current issue available at the time of Bid.

1. CMAA - Crane Manufacturers Association of America

2. AISC – “Manual of Steel Construction”

3. ASTM A48 - Standard Specifications for Gray Iron Castings

4 ANSI B30.11 - Safety Code for Underhung Cranes and Monorail Systems.

5 ANSI B30.16 - Safety Code for Overhead Hoists.

6. International Building Code with SC Modifications

1.04 SUBMITTALS

A. The Contractor shall submit Shop Drawings, Performance Affidavit, Operation and Maintenance Instructions and other information as specified in accordance with Section 01300, Submittals and Section 11000, Equipment General Provisions. Additional required information shall include: the horsepower, voltage, and rotative speed of the motor and the total weight of the equipment plus the approximate weight of the shipped materials. Shop Drawings shall also include complete erection, installation, and adjustment instructions and recommendations.

B. The Contractor shall submit confirmation that lifting hook intended to be used with trolley hoist is compatible with “Flygt Grip Eye” by Xylem US.

1.05 QUALITY ASSURANCE

A. The equipment covered by these Specifications are intended to be standard equipment of proven reliability and as manufactured by reputable manufacturers having experience in the production of such equipment. The equipment furnished shall be designed, constructed, and installed in accordance with the best practices and methods and shall operate satisfactorily when installed as shown on the Contract Drawings and operated per manufacturers recommendations.

B. The warrantee shall be per Section 01300.

1.06 CONTRACTOR'S RESPONSIBILITIES

A. The manufacturer and ultimately the Contractor shall be totally responsible for structural design of the hoist systems proposed. The Contractor shall submit certification that the systems have been designed to resist all loads implied herein and loadings stipulated in the South Carolina Building Code. The Certification shall also state that the design has been performed and sealed by a registered Professional Engineer in the State of South Carolina.

B. The Contractor shall provide the services of a qualified manufacturer's technical representative who shall adequately supervise the installation and testing of all equipment furnished under this Contract and instruct the Owner's operating personnel in its maintenance and operation as outlined in Division 1. The services of the manufacturer's representative shall be provided for a period of not less than two (2) days as follows:

1. At least one trip of one (1) days to supervise and approve the installation of the equipment.

2. One trip of one (1) day after acceptance of the equipment to supervise initial start-up and operation and instruct the Owner's personnel in proper operation and maintenance of the equipment.

C. Any additional time required to achieve successful installation and operation shall be at the expense of the Contractor. The manufacturer's representative shall sign in and out at the office of the Engineer's Resident Project Representative on each day he is at the project.

D. A written report covering the representative's findings and installation approval shall be mailed directly to the Engineer covering all inspection and outlining in detail any deficiencies noted.

E. The times specified are exclusive of travel time to and from the facility and shall not be construed as to relieve the manufacturer of any additional visits to provide sufficient service to place the equipment in satisfactory operation.

PART 2 -- PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Specifications provide products manufactured by one of the following: No exceptions.

1. ACCO Industries, Inc.
2. Electrolift, Inc.
3. Yale

2.02 GENERAL

A. The Contractor shall furnish and install hoist system(s) as shown on the Drawings and as specified in the Hoist Schedule, complete with all necessary accessories required for a complete and fully operational installation.

B. All equipment specified in this Section shall be designed and furnished by the hoist manufacturer who shall be responsible for the suitability and compatibility of all included equipment.

C. The trolley(s) and hoist system(s) shall be designed for lifting and moving parts of process equipment during servicing and/or replacement in the locations and conditions of service as specified in the Hoist Schedule located at the end of this Section.

2.03 TROLLEY DRIVE

A. The motor driven trolley shall include a 460V, 3-phase gear-motor with fluid drive couplings or solid-state soft start with adjustable time and torque, and electric brake. All load carrying parts shall be of steel. The wheels shall have hardened treads. Wheels and axles shall be equipped with antifriction bearings which are permanently sealed and lubricated. The gear head of the motor shall have an alloy steel, heat-treated gear train operating in a fully enclosed oil bath. The gear shaft shall have precision, oil lubricated ball bearings. Where monorail track as specified or shown on the Drawings is curved, trolleys shall be designed to negotiate curved sections

2.04 HOIST DRIVE

A. Hoist drive shall be of the two (2) speed, close-headroom, cross-mounted type and shall include a direct coupled motor, solenoid brake, geared train with inherent load brake, hook, drum and electrical controls. Rated capacity shall be stamped on the hoist frame. The frame shall be oil-tight, of cast steel construction, with no part of the load carried by assembly bolts. Gearing shall be machine cut and heat-treated, and shall operate in an oil bath. Except for the drum pinion, no gears shall be cantilever mounted. Shafting shall be ground and polished and all bearings shall be of the antifriction type. Grease fittings and oil reservoir shall be readily accessible. The drum shall be of the large diameter, guarded, flanged type with machine cut grooves to accommodate the hoist cable without overwrapping. The wire ropes shall be of the preformed extra flexible type, have a safety factor of at least five, and be anchored to the hoist drum. The load block shall be of the safety type with guarded sheaves and forged swiveled hooks. Hooks shall open slowly when subjected to heavy overloads.

B. The solenoid brake shall be spring set with magnetic release operated by and interlocked with the electrical control equipment. A worm gear drive with an inherent load brake designed in accordance with the Hoist Manufacturer's Institute standards shall be provided for controlling the speed when lowering, and for holding maximum hook load for any load up to capacity. Stressed parts shall be of cast or forged steel. In the event of a power failure the braking system shall automatically lock the piece of equipment being lifted to prevent further movement.

2.05 CONTROLS

A. Starting equipment shall be integral with the hoist unit and shall be of the full voltage, magnetic-reversing type with three overload elements. Equipment shall be housed in a NEMA 4X enclosure.

B. Pendent controls for lift and travel shall be provided complete with heavy-duty push-button station of constant pressure type with silver-to-silver contact elements, and sufficient control cable and chain for support of the control station at a point 4 feet above the lowest operating floor where multiple levels are to be accessed. A retracting cord reel shall be provided which will allow the control pushbutton station to be retracted to a maximum of four feet above the upper operating level. Two speed control of the hoist drive shall be effected by a two-step pushbutton.

C. Control power shall be 120 volt, provided by a control power transformer within the starter units. One side of this transformer shall be grounded, the other side shall be connected via a fuse of adequate rating.

2.06 ELECTRICAL EQUIPMENT

A. Electrical equipment and wiring shall comply with the latest National Electric Code and all motor operated equipment shall be wired by the hoist manufacturer. All electric motors shall conform to the applicable parts of Section 15170, Electric Motors. The system shall be designed for a single 460V, 3-phase, 60 Hz power connection. Hoisting motors shall be a two-speed squirrel cage induction motors with ball or roller bearings, and serviceable on 460V, 3-phase. The trolley motors shall be a single speed squirrel cage induction motors NEMA Design "D". Motors shall be of the totally enclosed type designed for hoist service. The motor rating shall be on a 30-minute 55°C, duty cycle basis. Motors shall be provided with 120V space heaters.

B. All wiring between motor, limit switches and starters shall be short, compact and protected by rigid galvanized steel conduit or flexible steel neoprene jacketed cable. Service power to the crane, hoist and trolley shall be by means of an insulated channel conductor type power feed system. Power

source connections shall be furnished with strain relief devices, where applicable. Wiring between the power feed system and hoisting equipment shall be by the hoisting equipment manufacturer.

C. Limit switches shall be approved geared typed, positive in action, compact, oil proof and readily accessible. Solenoid brakes shall be disk type, spring set with magnetic release. Solenoids shall be totally enclosed, protected from oil and moisture, readily accessible for adjustment and maintenance and shall develop the required forces without overheating.

2.07 PROTECTIVE ENCLOSURE

A. Install a weather protective enclosure for the hoist to be located at the end of the beam where the hoist will rest when it is not in use, as indicated on the Drawings.

2.08 ACCESSORIES

A. Other accessories shall include a stainless steel Flygt Grip-Eye System to facilitate pump lifting.

B. The wire rope and all other hardware that can enter the wet well shall be stainless steel.

2.09 SCHEDULE FOR TROLLEY HOIST SYSTEM(S)

A. Locations, dimensions, design criteria, number required, etc. for hoist system(s) are indicated in the Trolley and Hoist Schedule located at the end of this Section.

PART 3 -- EXECUTION

3.01 INSTALLATION

A. All hoist equipment, including protective enclosure, shall be installed in accordance with manufacturer's instructions and recommendations.

3.02 FIELD TESTS

A. Field tests shall be conducted in accordance with Section 01650, and manufacturer's instructions and recommendations. Prior to initial use, all hoists shall be proof-tested at 125% of their rated load in accordance with all OSHA requirements. Certification that the equipment has been tested and passed shall be submitted in accordance with Section 01300, Submittals.

3.03 TOOLS, SUPPLIES, AND SPARE PARTS

A. The Contractor shall furnish all special tools necessary to disassemble, service, repair and adjust the equipment, and any spare parts as recommended by the equipment manufacturer.

B. All of these materials shall by properly packed, labeled and stored where directed by the Engineer.

3.04 PAINTING

A. All equipment shall have manufacturer's standard finishes. Field painting shall be as specified in Section 09900, Painting.

## TROLLEY AND HOIST SCHEDULE

The trolley and hoist units shall be designated for the following conditions:

| **Location:** | **Berkeley County Water & Sanitation Pump Station** |
|---|---|
| Capacity (tons) | 2 |
| Minimum Lift (feet) | 35 |
| Operating Floor Elevation | 19.00 |
| Hook Elevation | |
| High Point | 18.0 |
| Low Point | -3.0 |
| Trolley Type | Motorized (Electrically Operated) |
| Hoist Type | Wire Rope (Electrically Operated) |
| Trolley Speed (fpm) | 60 |
| Trolley Motor HP (minimum) | 1/4 |
| Hoist Speed (fpm) | 18 and 6 |
| Hoist Motor HP (minimum) | 2 and 0.66 |

All elevations are approximate and all equipment shall be installed as shown on the Contract Drawings.

- END OF SECTION -

SECTION 15220

PUMP STATION VALVES AND PIPING

PART 1 -- GENERAL

1.01 SECTION INCLUDES

A. All exposed piping, valves, fittings, specials, and appurtenances.

B. Piping embedded in concrete within a structure or foundation will be considered as exposed and included herein.

C. Restraints, thrust blocks and kickers.

D. Testing.

E. All joints, specials, couplings, flexible couplings, mechanical couplings, harnessed and flanged adapters, sleeves, tie rods, joining and gasket materials and all other work required to complete installation of exposed piping.

F. All valves, gates, specials, sleeves, wall pipes and floor pipes shown or specified shall be incorporated into the piping system.

1.02 RELATED SECTIONS

A. Section 02733 – Sewer Forcemains

B. Section 02734 – Sewer Forcemain testing

1.03 QUALITY ASSURANCE

A. Comply with applicable requirements of UL and other authorities having jurisdiction.

1.04 REFERENCES

A. AWWA C206, Field Welding of Steel Water Pipe Joints.

B. AWS, D1.1, Structural Welding Code.

1.05 SUBMITTALS

A. Shop Drawings: Submit for approval for all piping, detailed drawings in plan and profile, and laying schedules. Show full details of piping, specials, and connections to existing pipes and structures.

B. Tests: Submit description of proposed testing methods, procedures and apparatus. Submit copies of all test reports.

C. Maintain record drawings in accordance with Section 1700.

1.06 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Handle all pipe, fittings and accessories carefully with approved handling devices. Do not drop or roll pipe off trucks. Do not otherwise drop, roll or skid pipe. Materials that are cracked, chipped, gouged, dented or otherwise damaged will not be approved.

B. Store pipe and fittings on heavy wood blocking or platforms so they are not in contact with the ground.

## PART 2 -- PRODUCTS

2.01 MATERIALS

A. Check valves – Check valves shall be 175 psi working pressure, flanged, bronze disc ring and seat ring, neoprene faced, weight and lever, cushioned swing operated type valves. The cushion chamber shall be attached to the side of the valve body externally and so constructed with a piston operating in a chamber that will effectively permit the valve to be operated without any hammering action. The shock absorption shall be by air, and the cushion chamber shall be so arranged that the closing speed will be adjustable to meet the service requirements. The valve shall be Figure 250-D by G.A. Industries or equivalent. Valves shall be AWWA approved.

B. Gate Valves – Gate valves shall be resilient wedge 250 psi working pressure, iron body, or bronze encapsulated with EPDM rubber, resilient wedge, with triple ‘0" rings stem seals. Valves shall conform to AWWA specification.

C. Plug Valves - Plug valves shall be Millcentric Series 601/600 as manufactured by Milliken Valve Company, or equal, and shall be non-lubricated eccentric type, flanged joint as per ANSI B16.1 Class 125/150, mechanical joint as per AWWA/ANSI C-111-92. Plug coating shall be BUNA-N material. Valve bodies shall be as per AWWA C-504-87. Valves shall be gear operated.

D. Piping – Piping shall be of the diameter as shown on the Drawings. Exposed piping shall be shop primed, asphaltic coating will not be allowed, and pipe interior shall be epoxy-lined with Protecto 401. Pipe sections shall be of D.I. flanged AWWA Class B with flanges cast or ASA Class 250 with 125 pounds standard screwed flanges. Ductile Iron Piping that is installed in vaults or above grade shall have flanged fittings rated to 250 psi.

E. Piping Supports – Exposed piping must be supported to prevent excessive piping loads from being transmitted to pumps or station piping. Buried force main piping must be supported with thrust blocks or restrained joint piping.

F. Fittings – Fittings shall be C.I. Class 125 ASA flanged fittings.

G. Pressure Gauge – Each pump discharge line shall be equipped with a tapped fitting, petcock, a diaphragm seal acceptable for wastewater applications, and a 4" glycerin filled pressure gauge reading in pounds per square inch (psi), with the range and scale appropriate for the application.

H. Non-Slam Air Release Valves – Non-Slam Air release valves shall be A.R.V., or equivalent. Size and location shall be as indicated on the Drawings.

## PART 3 -- EXECUTION

### 3.01 INSTALLATION

A. General:

1. Install piping as shown, specified and as recommended by the manufacturer.
2. Request instructions from OWNER before proceeding if there is a conflict between the manufacturer's instructions and the Drawings or Specifications.
3. Pipe, fittings and accessories that are cracked, damaged or in poor condition or with damaged linings will be rejected.
4. For specially fabricated piping Contractor shall provide the services of a competent manufacturer's installation specialist when pipe installation begins, unless otherwise approved by OWNER.
5. Conflicts between piping systems and equipment or structures shall be presented to OWNER for determination of corrective measures before proceeding.

B. Piping:

1. Install straight runs true to line and elevation.
2. Install vertical pipe truly plumb in all directions.
3. Install piping parallel or perpendicularly to building walls. Piping at angles and 45 degree runs across corners will not be accepted unless specifically shown or approved.
4. Install small diameter piping generally as shown when specific locations and elevations are not indicated. Locate such piping as required to avoid ducts, equipment, beams, etc.
5. Install piping so as to leave all corridors, walkways, work areas, and like spaces unobstructed. Unless otherwise approved provide a minimum headroom clearance under all piping of 7 feet 6 inches.
6. Provide temporary caps or plugs over all pipe openings at the end of each days work, and when otherwise required or directed by OWNER.
7. Cutting: Cut pipe from measurements taken at site, not from Drawings.
8. Pipe Marking:
   a. Class designation shall be cast or painted on each piece of pipe or fitting 4 inches in size or larger.

b. Each piece of pipe or fitting, except straight pipe with no outlets, shall be clearly marked with a designation that shall conform with designations shown on the Shop Drawings.
c. Piping, 3 inches diameter and less shall be clearly marked by manufacturer as to material, type and rating.

C. Joints:

1. General:
   a. Make joints in accordance with the pipe manufacturer's recommendations and the requirements below.
   b. Cut piping accurately and squarely and install without forcing or springing.
   c. Ream out all pipes and tubing to full inside diameter after cutting. Remove all sharp edges on end cuts.
   d. Remove all cuttings and foreign matter from the inside of pipes and tubing before installation. Thoroughly clean all pipe, fittings, valves, specials, and accessories before installing. Bell and spigot mating surfaces shall be thoroughly wire brushed and wiped clean and dry immediately before pipe is installed.
2. Flanged Joints: Assemble flanged joints with approved full-face gasket compounds and draw up flange bolts evenly.
3. Plastic Pipe Joints: For pipe sizes 1/2 inch to 2 inches in diameter shall be flange connection unless otherwise specified.
4. Weld Joints: Welding of steel pipe and fittings shall conform with all applicable requirements of Code for Pressure Piping, ANSI B31.1 Section 6 of AWWA C206.
5. All welders shall qualify for AR-2 class welding, ANSI B13.1, and shall have current certificate available for OWNER’s review.
6. Use hexagon head nuts and bolts on all flanged joints. Use 1/8- inch thick full-face gaskets unless otherwise approved by OWNER. Gaskets shall be suitable for service intended in accordance with manufacturer’s ratings and instructions.

D. Unions:

1. Install dielectric unions wherever dissimilar metals are connected except for bronze or brass valves in ferrous piping.
2. Provide a union downstream of each valve with screwed connections.
3. Provide screwed or flanged unions at each piece of equipment, where shown, and where necessary to install or dismantle piping.

E. Eccentric Reducers:

1. Use eccentric reducers where shown and where air or water pockets would otherwise occur in mains because of reduction in pipe size.

F. Valves and Accessories:

1. Provide supports for large valves, meters and other heavy items.
2. Install floor stands as shown and as recommended by the manufacturer.

3. Provide lateral restraints for extension bonnets and extension stems as shown and as recommended by the manufacturer.
4. Provide steel sleeves where operating stems pass through floor. Extend sleeves two inches above floor unless otherwise approved by OWNER.
5. Position valve operators as shown. When the position is not shown, install the valve so that it can be conveniently operated and as approved by Engineer. Avoid placing operators at angles to the floors or walls.
6. Position flow measuring devices in pipelines so that they have the amount of straight upstream and downstream runs recommended by the manufacturer, unless specific location dimensions are shown. Position the flow measuring devices so that they do not conflict with the discs of butterfly control valves.

G. Provide all necessary adapters, specials and connection pieces required when connecting different types and sizes of pipe or connecting pipe made by different manufacturers.

H. Restraints, Supports and Thrust Blocks:

1. Install restrained joints as shown, specified, or required and as recommended by manufacturer.
2. Provide concrete and metal cradles, collars, kickers, and blocks as shown or otherwise approved by OWNER.

3.02 TESTING OF PRESSURE PIPING

A. Test pipe in accordance with Section 02734 – Sewer Forcemain testing.

- END OF SECTION -

SECTION 16000

BASIC ELECTRICAL REQUIREMENTS

## PART 1 -- GENERAL

### 1.01 THE REQUIREMENT

A. The Contractor shall furnish all labor, materials, tools, and equipment, and perform all work and services necessary for, or incidental, to the furnishing and installation of all electrical work as shown on the Drawings, and as specified in accordance with the provisions of the Contract Documents and completely coordinate with the work of other trades involved in the general construction. Although such work is not specifically shown or specified, all supplementary or miscellaneous items, appurtenances, and devices incidental to or necessary for a sound, secure, and complete installation shall be furnished and installed as part of this work. The Contractor shall obtain approved Shop Drawings showing wiring diagrams, connection diagrams, roughing-in and hook up details for all equipment and comply therewith. All electrical work shall be complete and left in operating condition in accordance with the intent of the Drawings and the Specifications for the electrical work.

B. Where the word "Contractor" appears in these Technical Specifications it shall be construed to mean the Electrical Contractor.

C. THE CONTRACTOR SHALL REFERENCE THE FUNCTIONAL DESCRIPTIONS AND OTHER REQUIREMENTS FOUND IN DIVISIONS 11 AND 17, FOR ADDITIONAL REQUIREMENTS PERTAINING TO WORK UNDER THIS CONTRACT. THE FUNCTIONAL DESCRIPTIONS REFERENCED HEREIN SHALL BE CONSIDERED AS PART OF THE WORK REQUIRED UNDER THIS CONTRACT.

D. THE CONTRACTOR SHALL BE RESPONSIBLE FOR ALL INTERCONNECTING DEVICES, CONDUIT, WIRE, AND APPURTENANCES NOT FURNISHED BY OTHERS BUT REQUIRED FOR THE OPERATION OF EQUIPMENT AS DESCRIBED IN THE FUNCTIONAL DESCRIPTIONS WHETHER SPECIFICALLY SHOWN ON THE DRAWINGS OR NOT.

E. The scope of work for this project primarily includes, but is not limited to, the following:

1. Furnish and install new standby engine-generator in sound attenuated enclosure, automatic transfer switch, service entrance rated enclosed circuit breaker, and pump station control panel.

2. Furnish and install new low voltage motor control equipment including reduced voltage motor starters and variable frequency drives within pump station control panel.

3. Furnish and install lighting panelboards, dry-type transformers, and other low voltage electrical power distribution equipment.

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4. Furnish and install all aboveground raceway systems including conduit, fittings, boxes, and other pertinent components.

5. Furnish and install all underground raceway systems including conduit, fittings, handholes and other pertinent components.

6. Furnish and install all low voltage wire and cable resulting in a complete and operable electrical system.

7. Furnish and install new lighting systems and wiring devices.

8. Other electrical work as specified herein and indicated on the Drawings.

F. Maintaining the operation of these facilities during the duration of the construction period is essential and required. The Contractor shall furnish and install temporary equipment as required to maintain facility operation. Reference Section 01520 of the Specifications for construction sequencing and specific operational constraint information.

G. All electrical equipment shall conform to the applicable NEMA specifications. All electrical equipment shall be properly identified in accordance with these Specifications and Contract Drawings. All panelboards, starters, control panels, cabinet enclosures, junction boxes, pull boxes, and equipment switches shall be identified per the requirements of Section 16195 – Electrical Identification.

H. All materials, equipment, sizes and capacities of electrical equipment incorporated in the project shall conform to the latest requirements of the current National Electric Code, the National Electrical Manufacturer's Association, the State and local electrical codes, and to applicable rules and regulations of the local electrical utility serving the project.

I. All material and equipment must be the product of an established, reputable, and approved manufacturer; must be new and of first class construction; must be designed and guaranteed to perform the service required; and must bear the label of approval of the Underwriters Laboratories, Inc., where such approval is available for the product of the listed manufacturer as approved by the Engineer.

J. When a specified or indicated item has been superseded or is no longer available, the manufacturer's latest equivalent type or model of material or equipment as approved by the Engineer shall be furnished and installed at no additional cost to the Owner.

K. Where the Contractor's selection of equipment of specified manufacturers or additionally approved manufacturers requires changes or additions to the system design, the Contractor shall be responsible in all respects for the modifications to all system designs, subject to approval of the Engineer. The Contractor's bid shall include all costs for all work of the Contract for all trades made necessary by such changes, additions or modifications or resulting from any approved substitution.

L. Furnish and install controls for each piece of equipment requiring controls under this Contract. The controls shall be the size and type recommended by the manufacturer for the application and as otherwise specified or indicated on the Drawings. Refer to Divisions 1, 11, and 17 of the Specifications for control, connection and coordination descriptions and requirements.

M. Furnish and install all stands, racks, brackets, supports, and similar equipment required to properly serve the equipment which is furnished under this Contract, or equipment otherwise specified or indicated on the Drawings.

N. All electrical components and systems, including electrical equipment foundations, shall be designed to resist operational forces as well as lateral sway and axial motion from seismic and thermal forces.

1.02 DRAWINGS

A. The Contractor shall furnish, install, and place in satisfactory condition ready for operation, all conduits, cables, and all other material needed for the complete lighting, power, control and other electrical systems shown or indicated in the Contract Drawings. Additional conduits and the required wiring shall be installed by the Contractor wherever needed to complete the installation of the specific equipment furnished.

1.03 EQUIPMENT LOCATION

A. The Contractor shall carefully investigate the structural and finish conditions affecting all of his work and shall arrange such work accordingly. The Contractor shall refer to the entire Drawing set to verify openings, special surfaces, and location of other equipment, or other special equipment prior to roughing-in for panels, switches, and other outlets. The Contractor shall verify all equipment dimensions to ensure that proposed equipment will fit properly in spaces indicated. Any deviation from what is specifically shown on the Contract Drawings shall be approved by the Engineer.

1.04 LOCAL CONDITIONS

A. The Contractor shall examine the site and become familiar with conditions affecting the work. The Contractor shall investigate, determine, and verify locations of any overhead or buried utilities on or near the site, and shall determine such locations in conjunction with all public and/or private utility companies and with all authorities having jurisdiction. All costs, both temporary and permanent to connect all utilities, shall be included in the Bid. Costs for connecting the electrical service include, but are not limited to, meter base, CT cabinet, and underground conduits. Coordination with the serving utility is required prior to the Bid to ensure these items have been adequately accounted for in the Bid. The Contractor shall be responsible for scheduling and coordinating with the local utility for temporary and permanent services.

B. In addition, the Contractor shall relocate all duct banks, lighting fixtures, receptacles, switches, boxes, and other electrical equipment as necessary to facilitate the Work included in this project. Costs for such work shall be included in the Bid.

C. The Contractor is responsible for coordinating all electric utility equipment installations with the serving electric utility. The Contractor shall furnish and install all electric utility equipment required by the electric utility to be installed by the Contractor whether specifically shown on the Drawings or not. The Contractor shall furnish and install the following electrical utility equipment as a minimum:

1. Concrete transformer pads constructed as instructed by the electric utility.

2. Primary and secondary ductbank.

3. Metering equipment cabinets and/or bases.

4. Conduit and wire required from metering cabinet to metering current transformers and potential transformers.

5. Secondary conductors.

6. Secondary terminations.

The electric utility will furnish and install the following equipment:

1. Primary conductors and terminations.

2. Utility transformer.

The Contractor is responsible for ensuring all electric utility equipment and construction installed by the Contractor is furnished and installed in accordance with the electric utility's design specifications and requirements. The Contractor is fully responsible for coordinating his scope of work with the electric utility. Any additional required electric utility construction or equipment not specified herein or shown on the Drawings shall be supplied by the Contractor at no additional cost to the Owner.

The contact person at the serving electrical utility is:

Kevin Mims
Berkeley Electric Cooperative
843-761-82000

1.05 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions, Section 01300, Submittals and the requirements of the individual specification sections, the Contractor shall obtain from the equipment manufacturer and submit the following:

1. Shop Drawings

2. Operation and Maintenance Manuals

3. Special Tools List

4. Proposed Testing Methods and Reports of Certified Shop Tests.

5. Reports of Certified Field Tests.

6. Manufacturer's Representative's Certification.

B. Submittals shall be sufficiently complete in detail to enable the Engineer to determine compliance with Contract requirements.

C. Submittals will be approved only to the extent of the information shown. Approval of an item of equipment shall not be construed to mean approval for components of that item for which the Contractor has provided no information.

D. Some individual Division 16 specification sections may require a Compliance, Deviations, and Exceptions (CD&E) letter to be submitted. If the CD&E letter is required and shop drawings are submitted without the letter, the submittal will be rejected. The letter shall include all comments, deviations and exceptions taken to the Drawings and Specifications by the Contractor AND Equipment Manufacturer/Supplier. This letter shall include a copy of this specification section. In the left margin beside each and every paragraph/item, a letter "C", "D", or "E" shall be typed or written in. The letter "C" shall be for full compliance with the requirement. The letter "D" shall be for a deviation from the requirement. The letter "E" shall be for taking exception to a requirement. Any requirements with the letter "D" or "E" beside them shall be provided with a full typewritten explanation of the deviation/exception. Handwritten explanation of the deviations/exceptions is not acceptable. The CD&E letter shall also address deviations, and exceptions taken to each Drawing related to this Specification Section.

E. Seismic support design for all nonstructural electrical components (conduit, raceways, freestanding equipment, etc.) in accordance with building code requirements.

1.06 APPLICABLE CODES AND REQUIREMENTS

A. Conformance

1. All work, equipment and materials furnished shall conform with the existing rules, requirements and specifications of the Insurance Rating Organization having jurisdiction, the serving electrical utility company, the latest edition of the National Electrical Code (NEC), the National Electric Manufacturers Association (NEMA), the Institute of Electrical and Electronic Engineers (IEEE), the Insulated Cable Engineers Association (ICEA), the American Society of Testing Materials (ASTM), the American National Standards Institute (ANSI), the requirements of the Occupational Safety Hazards Act (OSHA), and all other applicable Federal, State and local laws and/or ordinances.

2. All material and equipment shall bear the inspection labels of Underwriters Laboratories, Inc., if the material and equipment is of the class inspected by said laboratories.

3. All work shall be in accordance with local codes.

B. Nonconformance

1. Any paragraph of requirements in these Specifications, or Drawings, deviating from the rules, requirements and Specifications of the above organizations shall be invalid and their (the above organizations) requirements shall hold precedent thereto. The Contractor shall be held responsible for adherence to all rules, requirements and specifications as set forth above. Any additional work or material necessary for adherence will not be allowed as an extra, but shall be included in the Bid. Ignorance of any rule, requirement, or Specification shall not be allowed as an

excuse for nonconformity. Acceptance by the Engineer does not relieve the Contractor from the expense involved for the correction of any errors which may exist in the drawings submitted or in the satisfactory operation of any equipment.

C. Certification

1. Upon completion of the work, the Contractor shall obtain certificate(s) of inspection and approval from the National Board of Fire Underwriters or similar inspection organization having jurisdiction and shall deliver same to the Engineer and the Owner.

1.07 PERMITS AND INSPECTIONS

A. The Contractor shall reference the General Conditions and Section 01010, Summary of Work.

1.08 TEMPORARY LIGHTING AND POWER

A. The Contractor shall reference the General Conditions and Section 01510, Temporary Utilities.

1.09 TESTS

A. Upon completion of the installation, the Contractor shall perform tests for operation, load (Phase) balance, overloads, and short circuits. Tests shall be made with and to the satisfaction of the Owner and Engineer.

B. The Contractor shall perform all field tests and shall provide all labor, equipment, and incidentals required for testing and shall pay for electric power required for the tests. All defective material and workmanship disclosed shall be corrected by the Contractor at no cost to the Owner. The Contractor shall show by demonstration in service that all circuits and devices are in good operating condition. Test shall be such that each item of control equipment will function not less than five (5) times.

C. The grounding system shall be tested to assure continuity and compliance with the contract requirements. Reference Section 16170, Grounding and Bonding, for specific testing requirements.

D. Insulation resistance testing of all incoming and outgoing cables for switchgear, motor control centers, lighting and power distribution panelboards, and similar equipment shall be done after the cables are in place and just prior to final terminations. All data shall be recorded, as per Exhibit "A", attached to the end of this Section. See Section 16123 for detailed requirements.

E. Feeder circuits shall be tested with the feeder conductors disconnected from the supplied equipment. Each individual power circuit shall be tested at the panel or motor control center with the power equipment connected for proper operation.

F. The equipment to be tested shall include, but not be limited to, the following:

- Low Voltage Enclosed Circuit Breakers

- Variable Frequency Drives and Related Motor Control Equipment
- Panelboards
- Conduit System
- Cable and Wire
- Grounding System
- General Purpose Dry Type Transformers
- Lighting Fixtures
- Packaged Engine Generator Systems
- Automatic Transfer Switches

G. Refer to each specific specification section for detailed field tests.

H. The Contractor shall complete the installation and testing of the electrical installation at least two (2) weeks prior to the start-up and testing of all other equipment. During the period between the completion of electrical installation and the start-up and testing of all other equipment, the Contractor shall make all components of the Work available as it is completed for their use in performing Preliminary and Final Field Tests.

I. Before each test commences, the Contractor shall submit a detailed test procedure, and also provide test engineer resume, manpower and scheduling information for the approval by the Engineer. In addition, the Contractor shall furnish detailed test procedures for any of his equipment required as part of the field tests of other systems.

J. Just prior to the final acceptance of a piece of equipment, the Contractor shall perform an infrared inspection to locate and correct all heating problems associated with that electrical equipment.

The infrared inspection shall apply to all new equipment and existing equipment that is in any way modified under this Contract. All heating problems detected with new equipment furnished and installed under the Scope of this Contract shall be corrected by the Contractor. All problems detected with portions of existing equipment modified under this Contract shall also be corrected by the Contractor.

Any problems detected with portions of existing equipment that were not modified under this Contract are not the responsibility of the Contractor. Despite the Contractor not being held responsible for these problems, the Contractor shall report them to the Owner and Engineer immediately for resolution.

1.10 DOCUMENTATION

A. The work requirements of this Section is in addition to and does not supersede testing and adjusting specified in other portions of the Contract Documents. The Contractor shall submit to the Engineer test records and reports for all testing.

1.11 PROTECTIVE DEVICE SETTING AND TESTING

A. All protective devices in the electrical equipment shall be set, adjusted, calibrated and tested in accordance with the manufacturers' recommendations, the coordination study, and best industry practice.

B. Proper operation of all equipment associated with the device under test and its compartment shall be verified, as well as complete resistance, continuity and polarity tests of power, protective and metering circuits. Any minor adjustments, repairs and/or lubrication necessary to achieve proper operation shall be considered part of this Contract.

C. Circuit breakers and/or contactors associated with the above devices shall be tested for trip and close functions with their protective device.

D. When completed, the Contractor shall provide a comprehensive report for all equipment tested indicating condition, readings, faults and/or deficiencies in same. Inoperative or defective equipment shall be brought immediately to the attention of the Engineer.

E. Prior to placing any equipment in service, correct operation of all protective devices associated with this equipment shall be demonstrated by field testing under simulated load conditions.

1.12 SCHEDULES AND FACILITY OPERATIONS

A. In the event of accidental shutdown of Owner equipment, the Contractor shall notify Owner personnel immediately to allow for an orderly restart of affected equipment.

1.13 MATERIALS HANDLING

A. Materials arriving on the job site shall be stored in such a manner as to keep material free of rust and dirt and so as to keep material properly aligned and true to shape. Rusty, dirty, or misaligned material shall be rejected. Electrical conduit shall be stored to provide protection from the weather and accidental damage. Rigid non-metallic conduit shall be stored on even supports and in locations not subject to direct sun rays or excessive heat. Cables shall be sealed, stored, and handled carefully to avoid damage to the outer covering or insulation and damage from moisture and weather. Adequate protection shall be required at all times for electrical equipment and accessories until installed and accepted. Materials damaged during shipment, storage, installation, or testing shall be replaced or repaired in a manner meeting with the approval of the Engineer. If space heaters are provided in a piece of equipment, they shall be temporarily connected to a power source during storage. The Contractor shall store equipment and materials in accordance with Section 01550, Site Access and Storage.

(EXHIBIT A)
TEST DATA - MEGOHMS
TEST NO. ____

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Date: | | | Company: | | | | |
| Time: | | | Location: | | | | |
| Circuit: | Circuit Length: | Aerial: | Duct: | Buried: | No. of Conduc-tors | Size: | AMG MCM Shld: |
| Insulation Material: | | | Insulation Thickness: | | Voltage Rating: | | Age: |
| Type: _____Pothead _____Terminal | | | | | Location: Indoors_____ Outdoors_____ | | |
| Number and Type of Joints: | | | | | | | |
| Recent Operating History: | | | | | | | |
| Manufacturer: | | | | | | | |
| State if Potheads or Terminals were grounded during test: | | | | | | | |
| List associated equipment included in test: | | | | | | | |
| Miscellaneous Information: | | | | | | | |

(EXHIBIT A)
TEST DATA - MEGOHMS
TEST NO. ____

Part Tested:Test Made:_____
Hours/Days:_____
After Shutdown:_____

Grounding Time:Dry Bulb Temperature:_____
Wet Bulb Temperature:_____

Test Voltage:

Equipment Temperature: _____
How Obtained: _____
Relative Humidity: _____
Absolute Humidity: _____
Dew Point: _____

Megohmmeter: Serial Number: _____ Range: _____
Voltage: _____ Calibration Date_____

| Test Connections | To Line<br>To Earth<br>To Ground | To Line<br>To Earth<br>To Ground | To Line<br>To Earth<br>To Ground | Test Connections | To Line<br>To Earth<br>To Ground | To Line<br>To Earth<br>To Ground | To Line<br>To Earth<br>To Ground |
|---|---|---|---|---|---|---|---|
| 3 Minute | | | | 5 Minutes | | | |
| 2 Minute | | | | 6 Minutes | | | |
| 3/4 Minute | | | | 7 Minutes | | | |
| 1 Minute | | | | 8 Minutes | | | |
| 2 Minutes | | | | 9 Minutes | | | |
| 3 Minutes | | | | 10 Minutes | | | |
| 4 Minutes | | | | 10/1 Minutes | | | |
| | | | | Ratio | | | |

Remarks:

PART 2 -- PRODUCTS

2.01 PRODUCT REQUIREMENTS

A. Unless otherwise indicated, the materials to be provided under this Specification shall be the products of manufacturers regularly engaged in the production of all such items and shall be the manufacturer's latest design. The products shall conform to the applicable standards of UL and NEMA, unless specified otherwise. International Electrotechnical Commission (IEC) standards are not recognized. Equipment designed, manufactured, and labeled in compliance with IEC standards is not acceptable.

B. All items of the same type or ratings shall be identical. This shall be further understood to include products with the accessories indicated.

C. All equipment and materials shall be new, unless indicated or specified otherwise.

D. The Contractor shall submit proof if requested by the Engineer that the materials, appliances, equipment, or devices that are provided under this Contract meet the requirements of Underwriters Laboratories, Inc., in regard to fire and casualty hazards. The label of or listing by the Underwriters Laboratories, Inc., will be accepted as conforming with this requirement.

2.02 SUBSTITUTIONS

A. Unless specifically noted otherwise a, any reference in the Specifications or on the Drawings to any article, service, product, material, fixture, or item of equipment by name, make, or catalog number shall be interpreted as establishing the type, function, and standard of quality and shall not be construed as limiting competition. The Contractor, in such cases may, at his option use any article, device, product, material, fixture, or item of equipment which in the judgment of the Engineer, expressed in writing, is equal to that specified.

2.03 CONCRETE

A. The Contractor shall furnish all concrete required for the installation of all electrical work, Concrete shall be Class A unless otherwise specified. Concrete and reinforcing steel shall meet the appropriate requirements of Division 3 of the Specifications.

B. The Contractor shall provide concrete equipment pads for all free standing electrical apparatus and equipment located on new or existing floors or slabs. The Contractor shall provide all necessary anchor bolts, channel iron sills, and other materials as required. The exact location and dimensions shall be coordinated for each piece of equipment well in advance of the scheduled placing of these pads. Equipment pads shall be 4 inches high unless otherwise indicated on the Drawings and shall conform to standard detail for equipment pads shown on the Contract Drawings. Equipment pads shall not have more than 3” excess concrete beyond the edges of the equipment.

C. The Contractor shall provide concrete foundations for all free standing electrical apparatus and equipment located outdoors or where floors or slabs do not exist and/or are not or provided by others under this Contract. The Contractor shall provide all necessary anchor

bolts, channel iron sills, and other materials as required. The location and dimensions shall be coordinated for each piece of equipment well in advance of the scheduled placing of the foundations. Equipment foundations shall be constructed as detailed on the Drawings or if not detailed on the Drawings shall be 6 inches thick minimum reinforced with #4 bars at 12-inch centers each way placed mid-depth. Concrete shall extend 6 inches minimum beyond the extreme of the equipment base and be placed on a compacted stone bed (#57 stone or ABC) 6 inches thick minimum.

2.04 CABINETS AND ENCLOSURES

A. Ratings

1. Unless specified otherwise in these Specifications or shown on the Drawings, cabinets and enclosures shall be:

a. NEMA 4X stainless steel for all outdoor locations.

b. Suitable for the specific Class, Division, and Group when located in hazardous locations.

B. Construction – Stainless Steel

1. Enclosures shall be fabricated from stainless steel with seams that are continuously welded. Doors shall have full length piano hinges with the door removable by pulling the hinge pin.

2. A rolled lip shall be provided around three sides of the door and around all sides of the enclosure opening. The gasket shall be attached with oil-resistant adhesive and held in place with steel retaining strips. Exterior hardware, such as clamps, screws, and hinge pins, shall be stainless steel. Door latches for NEMA 4X cabinets and enclosures shall be all stainless steel, fast operating clamp assemblies that do not require bolts or screws to secure. A hasp and staple shall be provided for padlocking. Interior panels shall be provided. Each enclosure shall have a print pocket.

3. NEMA 4X enclosures and enclosures suitable for hazardous locations shall be unpainted.

PART 3 -- EXECUTION

3.01 CUTTING AND PATCHING

A. Coordination

1. The Work shall be coordinated between all trades to avoid delays and unnecessary cutting, channeling and drilling. Sleeves shall be placed in concrete for passage of conduit wherever possible.

B. Damage

1. The Contractor shall perform all chasing, channeling, drilling and patching necessary to the proper execution of his Contract. Any damage to the building, structure, or any equipment shall be repaired by qualified mechanics of the trades involved at the Contractor's expense. If, in the Engineer's judgment, the repair of damaged equipment would not be satisfactory, then the Contractor shall replace damaged equipment at his own expense.

C. Existing Equipment

1. Provide a suitable cover or plug for openings created in existing equipment as the result of work under this Contract. For example, provide round plugs in equipment enclosures where the removal of a conduit creates a hole and the enclosure. Covers and plugs shall maintain the NEMA rating of the equipment enclosure. Covers and plugs shall be watertight when installed in equipment located outdoors.

3.02 EXCAVATION AND BACKFILLING

A. The Contractor shall perform all excavation and backfill required for the installation of all electrical work. All excavation and backfilling shall be in complete accordance with the applicable requirements of Division 2.

3.03 CORROSION PROTECTION

A. Wherever dissimilar metals, except conduit and conduit fittings, come into contact, the Contractor shall isolate these metals as required with neoprene washers, nine (9) mil polyethylene tape, or gaskets.

- END OF SECTION -

SECTION 16111

CONDUIT

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. Under this Section, the Contractor shall furnish and install all conduits and conduit fittings to complete the installation of all electrically operated equipment as specified herein and as required.

B. The Drawings indicate the general location of conduits both exposed and concealed; however, the Contractor shall install these conduits in such a manner to avoid all interferences.

C. Reference Section 16000 – Basic Electrical Requirements and Section 16195 – Electrical Identification.

1.02 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the Contractor shall obtain from the equipment manufacturer and submit shop drawings. Each submittal shall be identified by the applicable Specification section.

1.03 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. Product data sheets.

2. Conduit identification methods and materials.

PART 2 -- PRODUCTS

2.01 MANUFACTURERS

A. The material covered by this Specification is intended to be standard material of proven performance as manufactured by reputable concerns. Material shall be fabricated, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as specified herein and shown on the Drawings.

2.02 CONDUITS

A. Unless specified otherwise herein, or indicated on the Drawings, all above ground conduits shall be rigid, heavily walled aluminum and all underground conduits shall be PVC. Minimum size conduit shall be 3/4 inch unless otherwise indicated on the Standard Details. Unless specified otherwise herein or indicated on the Drawings, all encased conduits shall be PVC Schedule 40, minimum size 1 inch. The Contractor, at his option, for ease of installation to accommodate saddle size, may increase the size of encased conduits to 2-inch. However, no combining of circuits/conductors will be permitted in these larger conduits.

All components of the conduit system shall be of the same material of construction. Aluminum conduit systems shall include fittings, couplings, connectors, and other components compatible with and approved for such systems. Coated conduit systems shall include factory coated fittings couplings, connectors, and other components compatible with and approved for coated conduit systems.

Reference the "Conduit Uses" portion of this specification for additional information regarding conduit.

B. Rigid Aluminum Conduit

1. Aluminum conduits shall be rigid type, heavy walled as manufactured by Allied Tube and Conduit Corporation, Wheatland Tube Company, Jones & Laughlin Steel Company, or approved equal.

2. Rigid aluminum conduit shalt be manufactured of 6063 alloy in temper designation T1. Fittings shall be of the same alloy.

3. Rigid aluminum conduit shall be listed by Underwriters' Laboratories to U.L. Standard 6A shall be manufactured to ANSI Standard C80.5.

4. Each length of conduit shall be shipped with a coupling on one end and a color coded thread protector at the other end.

C. Liquid-Tight Flexible Metal Conduit

1. Liquid-tight flexible conduit (LFMC) shall be galvanized steel, single strip, with a copper strip interwoven and suitable as a grounding means. LFMC shall be UL listed. LFMC shall have an extruded moisture and oil-proof PVC jacket. LFMC shall be Titan Type UL as manufactured by Southwire, Liquatite Type "LA" as manufactured by Electri-Flex, Anaconda Type UA as manufactured by Anamet Electrical, Inc., or equal.

2. PVC coated or stainless steel watertight connectors shall be used with liquid-tight flexible metal conduit on both ends. LFMC shall be used to connect all vibrating equipment installed outdoors, in wet or damp areas, and other applications as directed by the Engineer.

D. Conduit Fittings

1. Fittings for all conduit types shall conform to UL 467 and UL 514 as applicable.

2. Set screw or indentor type connectors shall not be used. Fittings for conduit installed in wet locations and underground shall provide a watertight joint. Fittings for rigid conduit shall be threaded.

3. Fittings or bushings shall be installed in easily accessible locations.

4. Conduit fittings ("condulets") shall be used on exposed conduit work for changes in direction of conduit runs and breaking around beams. "Condulets" shall be aluminum, as manufactured by Crouse-Hinds, OZ/Gedney, Appleton Company, or equal. In damp areas, the outside condulets shall be made watertight. Install all condulets with the covers accessible. Use proper tools to assemble conduit system to prevent injury to the covering. No damage to the covering shall be permitted.

5. Conduit fittings shall be cast type of non-ferrous metal or malleable iron thoroughly coated inside and outside with metallic zinc or cadmium after all machining has been completed. Cast fittings shall be provided with heavy threaded hubs to fit the conduit required. Covers shall be of the same material as the fittings to which they are attached and shall be screwed on with rubber or neoprene gaskets between the covers and fittings. Cast fittings 1-1/2 inches and above shall be of the "mogul" type.

6. Conduit seals shall be Type ES as manufactured by Crouse-Hinds, Appleton equivalent, OZ/Gedney equivalent, or equal.

## PART 3 -- EXECUTION

### 3.01 CONDUIT AND FITTINGS

A. Unless otherwise specified herein or indicated on the Drawings, the minimum size conduit shall be 3/4 inch for exposed work and 1 inch for conduit encased in concrete or mortar.

B. Conduit home runs for lighting circuits are not necessarily indicated on the Drawings; however, the circuit numbers are shown. Conduit shall be furnished and installed for these lighting circuits and shall be installed as required to suit field conditions, subject to review and acceptance by the Engineer.

C. Conduit shall be installed concealed unless otherwise indicated or specified. Conduit may be run exposed on walls only where concealing is not practical, or at the direction of the Engineer.

D. Where exposed, maintain a minimum distance of 6 inches from parallel runs of flues or water pipes. Conduit runs shall be installed in such locations as to avoid steam or hot water pipes. A minimum separation of 12 inches shall be maintained where conduit crosses or parallels hot water or steam pipes.

E. A non-metallic raceway containing instrumentation cable (if specifically allowed herein) where installed exposed shall be installed to provide the following clearances:

1. Raceway installed parallel to raceway conductors energized at 480 through 208 volts shall be 18 inches and 208/120 volts shall be 12 inches.

2. Raceway installed at right angles to conductors energized at 480 volts or 120/208 volts shall be 6 inches.

F. Where practical, exposed raceways containing instrumentation cable shall cross raceway containing conductors of other systems at right angles.

G. For floor mounted equipment, conduit may be installed overhead and dropped down, where underfloor installation is not practical. Groups of conduits shall be uniformly spaced, where straight and at turns. Conduit shall be cut with a hacksaw or an approved conduit-cutting machine and reamed after threading to remove all burrs. Securely fasten conduit to outlets, junction and pull boxes to effect firm electrical contact. Join conduit with approved couplings. Conduits shall be freed from all obstructions.

H. Empty conduit systems shall be furnished and installed as indicated on the Drawings and shall have pull ropes installed. The polyethylene pull ropes shall be ¼" diameter, minimum. Not less than 12 inches of slack shall be left at each end of the pull rope.

I. Each piece of conduit installed shall be free from blisters or other defects. Each piece installed shall be cut square, taper reamed, and a coat of galvanizing and conducting compound shall be applied to the threads. Galvanizing compound shall be CRC Zinc-It or equal. Threads on conduits shall be painted with a conducting compound prior to making up in a fitting. Conduit connections shall be made with standard coupling and the ends of the conduit shall butt tightly into the couplings. Where standard coupling cannot be used, Erickson three-piece couplings shall be used. Where conduits are installed in concrete, concrete-tight three-piece couplings shall be used.

J. Conduit threaded in the field shall be of standard sizes and lengths.

K. All bends shall be made with standard factory conduit elbows or field bent elbows. Field bending of conduit shall be done using tools approved for the purpose. Heating of conduit to facilitate bending is prohibited. Field bends shall be not less than the same radius than a standard factory conduit elbow. Bends with kinks shall not be acceptable.

The equivalent number of 90° bends in a single conduit run are limited to the following:

1. Runs in excess of 300 feet: 0

2. Runs of 300 feet to 201 feet: 1

3. Runs of 200 feet to 101 feet: 2

4. Runs of 100 feet and less: 3

L. Unless otherwise specified herein, indicated on the Drawings, or required by the NEC, conduit shall be supported every 8 feet (minimum) and shall be installed parallel with or

perpendicular to walls, structural members, or intersections of vertical planes and ceilings with right angle turns consisting of fittings or symmetrical bends. Conduits shall be supported within 1 foot of all changes in direction. Supports shall be approved pipe straps, wall brackets, hangers or ceiling trapeze. Pre-formed channels for outdoor service or damp/wet process areas shall be aluminum or Type 304 stainless steel. All fasteners, clamps, straps, and anchors shall be Type 304 stainless steel. Perforated strap hangers shall not be used.

N. In no case shall conduit be supported or fastened to another pipe or installed to prevent the removal of other pipe for repairs. Fastenings shall be by expansion bolts on concrete; by machine screws, welded threaded studs, or spring-tension clamps on steel work. Powder actuated fasteners may only be used to make connections where the use of this equipment complies with safety regulations and for structures in Seismic Design Categories A or B, unless the fasteners are approved for seismic use. Wooden plugs inserted in masonry and the use of nails as fastening media are prohibited. Threaded C-clamps may be used on rigid steel conduit only. Conduits or pipe straps shall not be welded to steel.

O. The load applied to fasteners shall not exceed 1/4 of the proof test load. Fasteners attached to concrete ceilings shall be vibration and shock resistant. Holes cut to a depth of more than 1-1/2 inches in reinforced concrete beams or to a depth of more than 3/4 inch in concrete joints shall not cut the main reinforcing bars. Holes not used shall be filled. Spring steel fasteners may only be used to support lighting branch circuit in EMT conduits to structural steel members. Conduits shall be fastened to all sheet metal boxes and cabinets with two (2) locknuts where required by the National Electrical Code to ensure adequate bonding for grounding. Where insulated bushings are used, or where bushings cannot be secured firmly to the box or enclosure, a bonding jumper shall be installed to maintain suitable grounding continuity. Locknuts shall be the type with sharp edges for digging into the wall of metal enclosures. Bushings shall be installed on the ends of all conduits and shall be of the insulating type where required by the National Electrical Code.

P. Conduit installed in concrete floor slabs or walls shall be located so as not to affect the designed structural strength of the slabs. Conduit shall be installed within the middle one-third of the concrete slab except where necessary to not disturb the reinforcement. The outside diameter of conduit shall not exceed one-third of the slab thickness, and conduits shall be spaced no closer than three (3) diameters except at cabinet locations. Curved portions of bends shall not be visible above the finish slab. Where embedded conduits cross expansion joints, suitable expansion/deflection fittings and bonding jumpers shall be provided. Conduit larger than 1-inch trade size shall be parallel with or at right angles to the main reinforcement. When at right angles to the reinforcement, the conduit shall be close to one of the supports of the slab. Conduits shall not be stacked more than two (2) diameters high in floor slabs. Embedded conduits shall be placed in accordance with the latest edition of ACI-318.

Q. Install aluminum conduits when entering or exiting concrete except under electrical equipment where the conduit is not subject to physical abuse. Also install aluminum conduit when transitioning between grade and a structure or an equipment stand. Extend stub-ups at least 12 inches above and below grade or finish floor. Conduits extending through the concrete floor shall be installed using straight runs (for vertical penetrations) or factory elbows (for conduits installed within the slab) of aluminum conduit.

R. Aluminum conduits shall not be in contact with concrete surfaces. Where aluminum is installed in concrete, conduits shall be appropriately coated. Where aluminum conduits are routed along concrete surfaces, they shall be installed with one hole cast straps with clamp-backs to space the conduit ¼" away from concrete surface. Where aluminum conduit passes through concrete, CMU or brick walls, the penetration shall be made such that the aluminum conduit does not come in contact with concrete, CMU, brick or mortar. All penetrations shall meet or exceed the UL design standards.

S. All conduit extending through the floor behind panels or into control centers or similar equipment may be PVC Schedule 40 and shall extend a minimum of 6 inches above the floor elevations, where practicable, with no couplings at floor elevations.

T. Unless specifically identified on the Drawings as "Direct Buried," all conduits in the earth, including conduits below slabs-on-grade, shall be concrete encased. Joints in conduit shall be staggered so as not to occur side by side. Rigid non-metallic (PVC) conduit shall be connected to aluminum conduit at the point where it leaves the ground, with the transition to metal conduit occurring inside the concrete encasement. Aluminum conduit shall be properly coated when encased in concrete.

U. No more than three (3) 90 degree bends will be allowed in any one conduit run. Where more bends are necessary, a condulet or pull box shall be installed. All bends in 3/4-inch conduit shall be made with a conduit bender, and all larger sizes shall have machine bends. Joints in threaded conduit shall be made up watertight with the appropriate pipe thread sealant or compound applied to male threads only; and, all field joints shall be cut square, reamed smooth, and properly threaded to receive couplings. No running threads are permitted. All conduit ends at switch and outlet boxes shall be fitted with an approved locknut and bushing forming an approved tight bond with box when screwed up tightly in place.

V. Conduits stubbed up through concrete floors for connections to freestanding equipment and for future equipment shall be provided with an adjustable top or coupling threaded inside for plugs, set flush with the finished floor. Screwdriver operated threaded flush plugs shall be installed in conduits from which no equipment connections are made.

W. Where outlets are shown near identified equipment furnished by this or other Contractors, it is the intent of the Specifications and Drawings that the outlet be located at the equipment to be served. The Contractor shall coordinate the location of these outlets to be near the final location of the equipment served whether placed correctly or incorrectly on the Drawings. Changes in outlet locations required to serve the equipment furnished by other Contractors on the Project shall be brought to the attention of the Engineer.

X. Conduit shall be protected immediately after installation by installing flat non-corrosive metallic discs and steel bushings, designed for this purpose, at each end. Discs shall not be removed until it is necessary to clean the conduit and install the conductors. Before the conductors are installed, insulated bushings shall be installed at each end of the conduit.

Y. Where "all-thread" nipples are used between fittings and electrical equipment, they shall be so installed that no threads are exposed.

Z. Connections from rigid conduit to motors and other vibrating equipment, limit switches, solenoid valves, level controls, and similar equipment, shall be made with short lengths of

liquid-tight flexible metal conduit. These conduits shall be installed in accordance with the NEC and shall be furnished and installed with appropriate connectors with devices which will provide an excellent electrical connection between the equipment and the rigid conduit for the flow of ground current. Flexible metal conduit and liquid-tight flexible metal conduit length shall be three (3) feet, maximum.

AA. Flexible metal conduit or liquid-tight flexible metal conduit installed between rigid metal conduit and motor terminal box and/or any other apparatus shall have a green insulated grounding conductor running through the flexible conduit. This conductor shall be terminated to the nearest pull box, motor terminal box, or any other apparatus ground terminal. Flexible metal conduit and liquid-tight flexible metal conduit shall be grounded and bonded per NEC Articles 348 and 350, respectively.

AB. Conduits installed within or underneath floor slabs, underground direct-buried or concrete encased conduits, and all conduits installed in areas subject to liquid inadvertently entering the conduit system shall be sealed or plugged at both ends in accordance with NEC Article 300-5(g). This requirement applies to both conduits containing conductors and "spare" conduits. Where practicable, the interior of the conduit shall be sealed as well as around the conductors by using conduit sealing bushings: Type CSB as manufactured by O/Z Gedney, or equal. Where the conduit fill does not allow the use of these bushings, the conduits shall be tightly caulked or plugged.

AC. Weatherproof, insulated throat "Meyers" hubs shall be used on all conduit entries to boxes and devices without integral hubs in process areas to maintain NEMA 4X integrity. The Contractor shall furnish and install "Meyers" hubs on all conduit entries into non-cast enclosures such as metallic or non-metallic control panels, control component enclosures, wireways, pull boxes, junction boxes, control stations, and similar type equipment when this type of equipment is located in process areas requiring NEMA 4X integrity. This specified requirement for "Meyers" hubs does not apply to any area of the plant facilities where NEMA 4X integrity is not required.

AD. The use of two (2) locknuts, one on each side of the enclosure, and a grounding bushing shall be required at all conduit terminations where hub type fittings are not required; such as electrical rooms, control rooms, and office areas.

AE. Conduit installation shall be arranged to minimize cleaning. No horizontal runs of conduit will be permitted in brick or masonry walls.

AF. Install non-metallic conduits in accordance with manufacturer's instructions where specified herein or indicated on the Drawings.

AG. Join non-metallic conduit using cement as recommended by the manufacturer. Clean and wipe non-metallic conduit dry before joining. Apply full even coat of cement to entire area inserted in fitting. Allow joint to cure for twenty (20) minutes (minimum).

AH. Where flexible conduit is required in a Class 1, Division 1 Hazardous area, a type ECGJH braided flexible coupling shall be used, as manufactured by Crouse-Hinds. Braiding and ends shall be of stainless steel construction. Couplings using un-coated copper braid are not acceptable.

AI. The Contractor shall furnish and install conduit entering or leaving NEC Article 500 hazardous areas with conduit seals.

3.02 CONDUIT USES AND APPLICATIONS

A. No PVC conduit shall be installed exposed unless specifically accepted in writing by the Engineer.

B. All power, control and instrumentation wire and cable shall be installed in rigid, heavy walled aluminum conduit. This applies to all conduit installations including exposed, concealed in concrete encasement, direct buried, and all other applications. All aluminum conduits direct buried or in concrete encasement shall be properly coated.

C. Other conduit uses not specifically listed above shall be brought to the attention of Engineer for a decision.

3.03 TESTING

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

1. Field Tests

a. Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 1, and Section 16000, Basic Electrical Requirements.

b. All conduit installed below grade or concrete encased shall be tested to ensure continuity and the absence of obstructions by pulling through each conduit a swab followed by a mandrel 85% of the conduit inside diameter. After testing, all conduits shall be capped after installation of a suitable pulling tape.

- END OF SECTION -

SECTION 16118

UNDERGROUND ELECTRICAL

## PART 1 -- GENERAL

### 1.01 THE REQUIREMENT

A. The Contractor shall furnish and install underground duct systems as specified herein and as indicated on the Drawings. The work shall be complete and shall include excavation, concrete construction, backfilling, and all materials, items, and components required for a complete system.

B. The provisions of this Division are applicable to all underground conduit work. All work shall be coordinated with that of the various utility companies and other Contractors. The Contractor shall adhere to all utility company requirements including the serving electric utility.

C. Reference Section 16000, Basic Electrical Requirements, Section 16111, Conduit, and the applicable sections of Division 2, Sitework and Division 3, Concrete.

### 1.02 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the Contractor shall obtain from the equipment manufacturer and submit Shop Drawings. Each submittal shall be identified by the applicable Specification Section.

### 1.03 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.

## PART 2 -- PRODUCTS

### 2.01 MANUFACTURERS

A. The material covered by this Specification is intended to be standard material of proven performance as manufactured by reputable concerns. Material shall be fabricated, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as specified herein and indicated on the Drawings.

### 2.02 DUCT SYSTEM

A. Underground duct system shall consist of parallel runs of Schedule 80 PVC conduit or properly coated aluminum conduit encased in concrete envelopes, unless otherwise specified herein or indicated on the Drawings.

B. Nonmetallic conduit joints shall be made with standard Schedule 80 PVC couplings and PVC solvent cement of the same manufacturer as the conduit. All PVC conduit shall be supplied by the same manufacturer. All joints shall be staggered, installed in accordance with the manufacturer's recommendations, and made watertight.

C. Base and intermediate conduit spacers shall be furnished to provide a minimum of two-inch (2") separation between conduits. Conduit spacers shall be provided in the proper size as required for the conduit that they secure. For example, a 4" conduit spacer shall not be used to secure a 2" conduit. Conduit spacers shall be as manufactured by Carlon Electrical Products Company, Aeroquip Corporation, Underground Devices, Incorporated, or equal.

## PART 3 -- EXECUTION

### 3.01 GENERAL

A. The underground duct system shall be installed as specified herein, indicated on the Drawings, and in accordance with manufacturers' instructions.

### 3.02 DUCT SYSTEM

A. All underground conduit shall be encased in concrete with a minimum of four (4) inches of concrete cover to the conduits. Concrete encased duct banks shall be reinforced as indicated on the Drawings.

B. Partial concrete pours, in general, shall not be permitted. Where a complete pour is impractical, written authorization shall be obtained from the Engineer for the partial pour.

C. Slope all conduits continuously away from structures and buildings with a minimum slope of 3" per 100' unless otherwise indicated on the Drawings.

D. In general, the minimum clearance from the top of the concrete encasement and finished grade shall be 24" except where otherwise accepted by the Engineer or shown on the Drawings.

E. Care shall be exercised during excavation for the duct banks to prevent digging too deep. Backfilling of low spots with earth fill will not be permitted unless thoroughly compacted and acceptable to the Engineer.

F. Conduits leaving or entering a structure may be shown in a different arrangement as compared to the duct bank. The Contractor shall arrange conduits penetrating the structure based on field conditions. The Drawings are not meant to represent actual conduit arrangements required unless noted as such. Furthermore, spare conduits from duct banks into structures are required and shall be furnished and installed based on field conditions and Engineer approval.

G. All ground rods shall be interconnected by means of the No. 4/0 AWG bare copper ground cable located within each duct bank. The ends of these cables shall also be connected to substation and/or ground buses where the conduits terminate.

H. Care shall be exercised and temporary plugs shall be installed during installation to prevent the entrance of concrete, mortar, or other large particles of matter into the conduit systems. Conduit spacers shall be utilized to support conduit during the pouring of concrete to prevent movement and misalignment of the conduits. Conduit spacers shall be installed in accordance with manufacturer's instructions unless otherwise noted. Horizontal spacing of conduit spacers along ductbank shall be as indicated on the Standard Details.

I. Prior to pulling cables, the Contractor shall thoroughly clean the inside of each length of conduit by swabbing. The ends of each conduit shall then be temporarily plugged to prevent the entrance of any dirt or foreign matter.

J. After all cables have been installed, all unused conduit openings shall be sealed or plugged as specified in Section 16111. A 250 lb. test pull rope shall be provided in the entire length of all unused conduits.

K. Six (6) inches above all duct banks, the Contractor shall furnish and install a two (2) inch wide red plastic electrical hazard tape. Tapes shall be metallic detectable type and shall have a continuous message in bold black letters: "ELECTRIC LINE BURIED BELOW." Tape shall be Detectable Identoline by Brady, or equal.

L. The Contractor shall perform all earthwork including excavation, backfill, bedding, compaction, shoring and bracing, grading and restoration of surfaces and seeded areas disturbed during the execution of the work.

3.05 TESTING

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

1. Field tests

a. Field tests for all completed duct systems shall consist of pulling a swab through each conduit followed by a mandrel equal in size to 85% of the conduit inside diameter.

b. After testing, all conduits shall be capped after installation of a suitable pull rope. All field tests shall be witnessed by the Engineer.

- END OF SECTION -

SECTION 16123

BUILDING WIRE AND CABLE

## PART 1 -- GENERAL

### 1.01 THE REQUIREMENT

A. The Contractor shall furnish, install, connect, test, and place in satisfactory operating condition, ready for service, all cables and wires indicated on the Drawings and as specified herein or required for proper operation of the installation, with the exception of internal wiring provided by electrical equipment manufacturers. The work of connecting cables to equipment, machinery, and devices shall be considered a part of this Section. All hardware, junction boxes, bolts, clamps, insulators, and fittings required for the installation of cable and wire systems shall be furnished and installed by the Contractor.

B. The wire and cable to be furnished and installed for this project shall be the product of manufacturers who have been in the business of manufacturing wire and cable for a minimum of ten (10) years.

C. Reference Section 16000, Basic Electrical Requirements.

### 1.02 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the Contractor shall obtain from the wire and cable manufacturer and submit the following:

1. Shop Drawings

2. Reports of Field Tests

3. Wiring Identification Methods

B. Each submittal shall be identified by the applicable specification section.

### 1.03 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed material's compliance with the Contract Documents.

B. Partial, incomplete, or illegible Submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. Product data sheets.

2. Wiring identification methods and materials.

1.04 IDENTIFICATION

A. Each cable shall be identified as specified in Part 3, Execution, of this Specification.

PART 2 -- PRODUCTS

2.01 MANUFACTURERS

A. The wire and cable covered by this Specification is intended to be standard equipment of proven performance. Wire and cable shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as specified herein and indicated on the Drawings. Only one (1) manufacturer for each wire and cable type shall be permitted.

B. The wire and cable manufacturer shall be ISO 9000 registered.

2.02 600 VOLT POWER WIRE AND CABLE

A. 600 volt power cable and wire installed between the output terminals of a VFD and the respective motor shall consist of stranded copper conductor with insulation type XHHW/XHHW-2, rated 90°C.

B. 600 volt power cable and wire for all other loads shall consist of stranded, copper conductor with insulation type THWN, 75°C for wet locations.

C. Conductors shall be stranded copper per ASTM-B8 and B-33, and Class B or C stranding contingent on the size unless otherwise specified. Minimum size wire shall be No. 12 AWG.

D. 600 volt individual power wire and cable shall be Okoseal-N as manufactured by the Okonite Company, Cerro Wire and Cable equivalent, Southwire Company equivalent with SIMPull jacket, or equal. Multi-conductor power cables shall be Okoseal-N Type TC Cable as manufactured by the Okonite Company, Cerro Wire and Cable equivalent, Southwire Company equivalent, or equal.

2.03 600 VOLT CONTROL CABLE

A. 600 volt control cable shall consist of stranded, copper conductor with insulation type THWN, 75°C for wet locations. The individual conductors of the multiple conductor cable shall be color coded for proper identification. Color coding shall be equal to ICEA S-68-514, Method 1, E2. Cables shall meet requirements of IEEE-383.

B. Conductors shall be stranded copper per ASTM B-8 and B-33, and Class B or C stranding contingent on the size unless otherwise specified. Minimum wire size shall be No. 14 AWG.

C. 600 volt individual conductor control wire shall be Okoseal-N as manufactured by the Okonite Company, Cerro Wire and Cable equivalent, Southwire Company equivalent with SIMPull jacket, or equal. Multi-conductor control cable shall be Okoseal-N Type TC Cable as manufactured by the Okonite Company, Cerro Wire and Cable equivalent, Southwire Company equivalent, or equal.

2.04 LIGHTING AND RECEPTACLE WIRE AND CABLE

A. The lighting and receptacle branch circuit wire shall consist of solid, copper conductors with insulation type THWN, 75°C for wet locations.

B. Conductors shall be solid copper per ASTM- B-33. Minimum size wire shall be No. 12 AWG.

C. Lighting and receptacle cables and wire shall be Okoseal-N as manufactured by the Okonite Company, Cerro Wire and Cable equivalent, Southwire Company equivalent with SIMPull jacket, or equal.

2.05 INSTRUMENTATION CABLE

A. The instrumentation cable for analog signals shall be single, shielded, twisted pairs or triads with 600 volt insulation and shall have a 90°C insulation rating.

B. Conductors shall be tin or alloy coated (if available), soft, annealed copper, stranded per ASTM-B8, Class B stranding unless otherwise specified. Minimum size wire shall be No. 16 AWG.

C. The instrumentation cable shall be Okoseal-N Type P-OS for single pair or triad applications and Okoseal-N Type SP-OS for multiple pair or triad applications as manufactured by the Okonite Company, Cerro Wire and Cable equivalent, Southwire Company equivalent, or equal.

2.06 CABLE PULLING LUBRICANTS

A. Cable pulling lubricants shall be non-hardening type and approved for use on the type of cable installed. Lubricant shall be Yellow #77 Plus by Ideal, Cable Gel by Greenlee, Poly-Gel by Gardner Bender, or equal.

PART 3 -- EXECUTION

3.01 600V POWER, CONTROL, AND LIGHTING/RECEPTACLE WIRE AND CABLE INSTALLATION

A. The cable and wires shall be installed as specified herein and indicated on the Drawings.

B. The cables shall be terminated in accordance with the cable and/or termination product manufacturer's instructions for the particular type of cable.

C. To minimize oxidation and corrosion, wire and cable shall be terminated using an oxide-inhibiting joint compound recommended for "copper-to-copper" connections. The compound shall be Penetrox E as manufactured by Burndy Electrical, or equal.

D. Splices shall not be allowed in the underground manhole and handhole systems. If splices are required, the Contractor shall obtain approval in writing from the Engineer prior to splicing. Splicing materials shall be barrel type butt splice connectors and heat shrink tubing

as manufactured by 3M, Ideal, or equal. No splicing of instrumentation cable is allowed. The use of screw-on wire connectors (wire nuts) shall only be permitted for lighting and receptacle circuits. Reference Section 16130 for additional requirements regarding control wiring.

E. Wire and Cable Sizes

1. The sizes of wire and cable shall be as indicated on the Drawings, or if not shown, as approved by the Engineer. If required due to field routing, the size of conductors and respective conduit shall be increased so that the voltage drop measured at the load does not exceed 2-1/2%.

2. Minimum wire size within control panels, motor control centers, switchboards and similar equipment shall be No. 12 AWG for power and No. 14 AWG for control.

F. Number of Wires

1. The number of wires indicated on the Drawings for the various control, indication, and metering circuits were determined for general schemes of control and for particular indication and metering systems.

2. The actual number of wires installed for each circuit shall, in no case, be less than the number required; however, the Contractor shall add as many wires as may be required for control and indication of the actual equipment selected for installation at no additional cost to the Owner. The addition of conductors shall be coordinated with and approved by the Engineer to avoid violations of the NEC regarding conduit fill.

3. All spare conductors shall be terminated on the terminal blocks mounted within the equipment.

G. Wiring Identification

1. In addition to color coding, all wiring shall be identified at <u>each</u> point of termination. This includes but is not limited to identification at the source, load, and in any intermediate junction boxes where a termination is made. The Contractor shall meet with the Owner and Engineer to come to an agreement regarding a wire identification system prior to installation of any wiring. Wire numbers shall not be duplicated.

2. Wire identification shall be by means of a heat shrinkable sleeve. Sleeves shall have a white background with black text. Wire sizes #14 AWG through #10 AWG shall have a minimum text size of 7 points. Wire sizes #8 AWG and larger shall have a minimum text size of 10 points. Sleeves shall be of appropriate length to fit the required text. The use of handwritten text for wire identification shall not be permitted.

3. Sleeves shall be suitable for the size of wire on which they are installed. When installation is complete, sleeves shall be tightly affixed to the wire and shall not move. Sleeves shall be heat shrunk onto wiring with a heat gun approved for the application. Sleeves shall not be heated by any means which employs the use of an

open flame. The Contractor shall take special care to ensure that the wiring insulation is not damaged during the heating process.

4. Sleeves shall be installed prior to the completion of the wiring terminations and shall be oriented so that they can be easily read.

5. Sleeves shall be white polyolefin as manufactured by Brady, Seton equivalent, Panduit equivalent, or equal.

6. Where sleeves are not available in the size required for the wire, the Contractor shall use an adhesive label with a white background and black text. Text size shall be in accordance with the requirements listed above.

7. Adhesive labels, for the case when sleeves are not suitable for the wire size, shall be white permanent vinyl as manufactured by Brady, Seton equivalent, Panduit equivalent, or equal.

8. Wire identification in manholes, handholes, pull boxes, and other accessible components in the raceway system where the wiring is continuous shall be accomplished by means of a tag installed around the bundled group of conductors. Identification shall utilize a FROM-TO system. Each group of conductors shall consist of all of the individual conductors in a single conduit or duct. The tag shall have text that identifies the bundle in accordance with the 'FROM' and 'TO' column for that particular conduit number in the conduit and wire schedule. Minimum text size shall be 10 point. The tag shall be affixed to the wire bundle by the use of nylon wire ties, and shall be made of polyethylene as manufactured by Brady, Seton equivalent, Panduit equivalent, or equal.

H. Cable Installation

1. All interior cable not protected by a compartment enclosure shall be installed in conduit.

I. Wiring Supplies

1. Only electrical wiring supplies manufactured under high standards of production and meeting the approval of the Engineer shall be used.

2. Rubber insulating tape shall be in accordance with ASTM Des. D119. Friction tape shall be in accordance with ASTM Des. D69.

J. Training of Cable

1. The Contractor shall furnish all labor and material required to train cables around cable vaults within buildings and in manholes and handholes in the outdoor underground duct system. Sufficient length of cable shall be provided in each handhole, manhole, and vault so that the cable can be trained and racked in an approved manner. Instrumentation cable shall be racked separate from all other AC and DC wiring to maintain the required separation specified herein. In training or racking, the radius of bend of any cable shall be not less than the manufacturer's

recommendation. The training shall be done in such a manner as to minimize chaffing. Reference Section 16118.

K. Connections at Control Panels, Limit Switches, and Similar Devices

1. Where stranded wires are terminated at panels, and/or devices, connections shall be made by solderless lug, crimp type ferrule, or solder dipped.

2. Where enclosure sizes and sizes of terminals at limit switches, solenoid valves, float switches, pressure switches, temperature switches, and other devices make 7-strand, No. 12 AWG, wire terminations impractical, the Contractor shall terminate external circuits in an adjacent junction box of proper size complete with terminal strips and shall install No. 14 AWG stranded wires from the device to the junction box in a conduit. The #12 AWG field wiring shall also be terminated in the same junction box to complete the circuit.

L. Pulling Temperature

1. Cable shall not be flexed or pulled when the temperature of the jacket is such that damage will occur due to low temperature embrittlement. When cable will be pulled with an ambient temperature of 40°F or less within a three (3) day period prior to pulling the cable reels shall be stored three (3) days prior to pulling in a protected storage area with an ambient temperature of 55°F or more. Cable pulling shall be completed during the work day for which the cable is removed from the protected storage. Any remaining cable reels shall be returned to storage at the completion of the workday.

M. Color Coding

1. Conductor insulation shall be color coded as follows:

a. 480/277V AC Power

Phase A - BROWN
Phase B - ORANGE
Phase C - YELLOW
Neutral - GREY

b. 120/208V or 120/240V AC Power

Phase A - BLACK
Phase B - RED
Phase C - BLUE
Neutral - WHITE

c. DC Power

Positive Lead - RED
Negative Lead - BLACK

d. DC Control

All wiring - BLUE

e. 120VAC Control

Single conductor 120 VAC control wire shall be RED except for a wire entering a motor control center compartment or control panel which is an interlock. This conductor shall be color coded YELLOW.

f. 24VAC Control

All wiring - ORANGE

g. Equipment Grounding Conductor

All wiring - GREEN

2. Conductors No. 2 AWG and smaller shall be factory color coded with a separate color for each phase and neutral, which shall be used consistently throughout the system. Larger cables shall be coded by the use of colored tape in accordance with the requirements listed above.

3. Low voltage feeder and branch circuit conductors shall be identified in accordance with the NEC. The method utilized for conductor identification for each nominal voltage system shall be permanently posted at each feeder or branch circuit distribution equipment assembly. Reference Articles 200, 210, and 215 of the NEC.

3.02 INSTRUMENTATION CABLE INSTALLATION

A. The Contractor shall install all cable or conductors used for instrumentation wiring (4-20 mA DC, etc.) in aluminum conduit. The use of asbestos cement or PVC conduit shall not be permitted. Analog signal wires shall exclusively occupy these conduits. No other wiring for AC or discrete DC circuits shall be installed in these conduits.

B. All shielding shall be continuous and shall be grounded at one point only, or in accordance with the instrumentation equipment manufacturer's recommendations.

C. Where instrumentation cables are installed in panels the Contractor shall arrange wiring to provide maximum clearance between these cables and other conductors. Instrumentation cables shall not be installed in same bundle with conductors of other circuits.

D. Where required or specifically directed by the Engineer, the Contractor shall moisture seal the cables at all connections with OZ Gedney Type "CSB", or equal, sealing bushings.

E. Special instrument cable shall be as specified or recommended by the manufacturer of the equipment or instruments requiring such wiring. Installation, storage, terminations, etc., shall be per manufacturer's recommendations.

F. All cable insulation and jackets shall have adequate strength for it to be pulled through the conduit systems. All conductors shall be color coded and all wires shall be suitably tagged with permanent markers as specified herein.

3.04 TESTING

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

1. Shop Test

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

2. Field Tests

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

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

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

(2) 600V instrumentation signal cable shall be tested from conductor to conductor, conductor to shield, and conductor to ground using a Simpson No. 260 volt-ohmmeter, or approved equal. The resistance value shall be 200 Megaohms or greater.

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

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

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

- END OF SECTION -

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SECTION 16141

WIRING DEVICES

## PART 1 -- GENERAL

### 1.01 THE REQUIREMENT

A. The Contractor shall furnish and install all switches and receptacles for lighting and miscellaneous power applications of the type and at the locations as specified herein and as shown on the Drawings.

B. All switches and receptacles shall be furnished and installed in outlet boxes as specified in Section 16130, Boxes.

C. Reference Section 16000, Basic Electrical Requirements.

### 1.02 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the Contractor shall obtain from the equipment manufacturer and submit shop drawings. Each submittal shall be identified by the applicable specification section.

### 1.03 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include, but not be limited to:

1. Product data sheets.

### 1.04 SUPPLIES AND SPARE PARTS

A. The Contractor shall furnish 10% (minimum of 1) spare of each receptacle, switch, and plug furnished and installed for this project.

B. Spare parts lists, included with the shop drawing submittal, shall indicate specific sizes, quantities, and part numbers of the items to be furnished. Terms such as "1 lot of packing material" are not acceptable.

C. Parts shall be completely identified with a numerical system to facilitate parts inventory control and stocking. Each part shall be properly identified by a separate number. Those parts which are identical for more than one size shall have the same parts number.

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1.05 IDENTIFICATION

A. Each switch and receptacle shall be identified with the equipment item number, manufacturer's name or trademark, and such other information as the manufacturer may consider necessary, or as specified, for complete identification.

PART 2 -- PRODUCTS

2.01 MANUFACTURERS

A. The equipment covered by these Specifications is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

B. The Contractor shall use the products of a single manufacturer for each type of wiring device.

C. The Contractor shall use the products of a single manufacturer for all device plates. Plate variations are allowed for the following devices:

1. Where the selected plate manufacturer does not manufacture a suitable finish plate.

2. For heavy-duty receptacles rated at more than 30A.

3. Where non-standard plates are required, specified, or shown.

D. The Contractor shall furnish and install all wiring devices and device plates. Wiring devices as listed herein are intended to indicate type, function, and quality of the products.

E. The receptacles, switches, device plates, and other appurtenances shall comply with the requirements of these Specifications. Receptacles installed in toilet, locker, and bathrooms shall be of ground fault interrupter type to meet the minimum NEC requirements. Ground fault circuit interrupter receptacles shall also be furnished and installed as specified herein, indicated on the Drawings, and required by the NEC.

F. Wiring devices shall be approved for use with stranded conductors, if stranded conductors are to be used with the device. Reference Section 16123, Building Wire and Cable.

G. The Contractor shall provide specification grade devices which shall be as manufactured by Appleton, Crouse-Hinds, Leviton, Harvey Hubbell Co., Bryant Electric Company, Pass & Seymour, or equal.

2.02 WIRING DEVICES

A. Wiring devices shall be in accordance with the following for nonhazardous areas:

1. Wall Switches, Single Pole, 20 A, 120-277V equivalent to Hubbell No. 1221, Pass & Seymour No. 20AC1, Leviton equivalent, or equal. Switches rated 30 A, 120-277V shall be Leviton 3031, Hubbell equivalent, Pass & Seymour equivalent, or equal.

2. Convenience Receptacles 20 A, 125V, duplex polarized with grounding connection equivalent to Hubbell No. 5362, Pass & Seymour equivalent, Leviton equivalent, or equal.

3. Hubbell Cat. No. GF-5362, Pass & Seymour equivalent, Leviton equivalent, or equal, for 20A, 120V, duplex, ground fault circuit interrupting type.

2.03 DEVICE PLATES

A. Wall plates with gaskets for flush-mounted receptacles and switches shall be made of Type 304 stainless steel, not less than 0.032 of an inch thick, with beveled edges and milled on the rear so as to lie flat against the wall. Wall plates shall be equivalent to Hubbell Series 9600, Pass & Seymour series 93000, Leviton equivalent, or equal.

B. Device plates for outdoor installations and indoor wet process area installations shall be Appleton Type FSK, Crouse-Hinds #DS185, or equal for wall switches. Device plates for receptacles shall be “in-use” style. “In-use” weatherproof covers shall be rugged, minimum 3 ¼” depth, die-cast aluminum as manufactured by Thomas & Betts "Red Dot," Intermatic International, Inc., or equal.

2.04 PLUGS

A. The Contractor shall furnish suitable plugs with equipment furnished under the respective Contract. Plugs shall be black rubber or plastic. For waterproof receptacles, the plugs shall be similar in construction to the receptacles and shall be encased in corrosion resistant yellow housing provided with clamping nuts and stuffing gland cable outlets.

2.05 PROCESS INSTRUMENTS

A. The Contractor shall furnish and install a local disconnect switch at each process instrument (e.g., level transmitter, flow transmitter, analytical instrument etc.,) to disconnect the 120VAC power supply to the instrument. The device shall be a NSSC series manual motor starting switch without overload protection as manufactured by Crouse-Hinds, Appleton equivalent, or equal. For hazardous locations, the device shall be a front operated general use snap switch mounted in an EFS enclosure as manufactured by Crouse-Hinds, Appleton equivalent, or equal.

PART 3 -- EXECUTION

3.01 INSTALLATION

A. Switch boxes shall be of unit construction and of sizes as required to adequately house the number of switches required. No sectional type switch boxes shall be permitted.

B. Where more than one (1) switch occurs at one (1) point, gang plates shall be used.

C. All device plates shall be set true and plumb, and shall fit tightly against the finished wall surfaces and outlet boxes.

D. All devices shall be flush-mounted in finished areas, unless otherwise noted. The Contractor shall determine the proper position of every outlet, and relocate any outlet without additional cost to the Owner if same is incorrectly or improperly located. The Engineer reserves the right to change the location of any outlet or connecting equipment up to the time of roughing in without additional cost to the Owner, provided conduit runs are not increased by more than ten (10) feet.

E. In all areas where thermal or acoustic insulation is applied to the ceiling or walls, outlet boxes shall be set to finish flush with the finished surface of the insulation.

F. When indicated height would place any of the equipment at an unsuitable location such as at a molding or break in wall finish, the contractor shall bring it to the attention of the Engineer for a decision.

G. For the below-named items, mounting heights from finish floor, or finish grade to top is applicable. Mounting heights shall be as follows, unless otherwise specified herein, indicated on the Drawings, or required by the Americans with Disability Act (ADA):

1. Single-pole light switches, 48 inches.

2. Duplex receptacles outdoors, 48 inches

H. The Contractor shall furnish and install switches as indicated on the Drawings. Switches shall be single pole, double pole, 3-way, or 4-way as indicated on the Drawings and as required. Switches located outdoors or in wet indoor locations shall be installed in cast boxes complete with yellow, fiberglass weatherproof covers. Reference Section 16141, Wiring Devices.

I. All receptacles shall have a self-adhesive label installed on the top at the respective device plate that indicates which panel and which circuit number the receptacle is supplied from. Labels shall have a white background and black lettering in 14 point font.

3.02 CIRCUITING

A. Convenience receptacles shall be grouped on circuits separate from the lighting circuits. A maximum of eight (8) convenience receptacles are permitted per 20A, 120V circuit.

- END OF SECTION -

SECTION 16170

GROUNDING AND BONDING

## PART 1 -- GENERAL

### 1.01 THE REQUIREMENT

A. The Contractor shall furnish and install grounding systems complete in accordance with the minimum requirements established by Article 250 of the NEC. Article 250 of the NEC shall be considered a minimum requirement for compliance with this Specification.

B. Grounding of all instrumentation and control systems shall be furnished and installed in accordance with the manufacturer/system requirements and IEEE 1100-92, Powering and Grounding of Sensitive Electronic Equipment. Conflicts shall be promptly brought to the attention of the Engineer.

C. In addition to the NEC requirements, building structural steel columns shall be permanently and effectively grounded.

D. Reference Section 16000, Basic Electrical Requirements.

### 1.02 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the Contractor shall obtain from the equipment manufacturer and submit the following:

1. Shop Drawings

2. Reports of certified field tests.

B. Each submittal shall be identified by the applicable specification section.

### 1.03 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.

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C. Shop drawings shall include but not be limited to:

1. Product data sheets.

2. Drawings and written description of how the Contractor intends to furnish and install the grounding system.

## PART 2 -- PRODUCTS

### 2.01 MANUFACTURERS

A. The equipment covered by these specifications shall be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

### 2.02 GROUND RODS AND GRID

A. Ground rods shall be rolled to a commercially round shape from a welded copper-clad steel manufactured by the molten-welding process or by the electro-formed process (molecularly bonded). They shall have an ultimate tensile strength of 75,000 pounds per square inch (psi) and an elastic limit of 49,000 psi. The rods shall be not less than 3/4 inch in diameter by 10 feet in length; and the proportion of copper shall be uniform throughout the length of the rod. The copper shall have a minimum wall thickness of 0.010 inch at any point on the rod. Ground rods shall be UL 467 listed. The ground rods shall be manufactured by Erico Products, Blackburn, or equal.

B. Except where specifically indicated otherwise, all exposed non current-carrying metallic parts of electrical equipment, metallic raceway systems, grounding conductors in nonmetallic raceways and neutral conductors of wiring systems shall be grounded.

C. The ground connection shall be made at the main service equipment and shall be extended to the ground grid surrounding the structure. The ground grid shall also be connected to the point of entrance of the metallic water service. Connection to the water pipe shall be made by a suitable ground clamp or lug connection to a plugged tee. If flanged pipes are encountered, connection shall be made with the lug bolted to the street side of the flanged connection.

D. Where ground fault protection is employed, care shall be taken so that the connection of the ground and neutral does not interfere with the correct operation of the ground fault protection system.

### 2.03 FITTINGS

A. Grounding connections to equipment shall be bolted. Cable end connections shall be made by hydraulic crimp or exothermically welded. Split bolt type connectors are not acceptable. Fittings shall be UL 467 listed.

2.04 EQUIPMENT GROUNDING CONDUCTORS

A. A green, insulated equipment grounding conductor, which shall be separate from the electrical system neutral conductor, shall be furnished and installed for all circuits. Equipment grounding conductors shall be furnished and installed in all conduits. Use of conduits as the NEC required equipment grounding conductor is not acceptable.

2.05 EQUIPMENT GROUNDS

A. Equipment grounds shall be solid and continuous from a connection at earth to all distribution panel boards. Ground connections at panelboards, outlets, equipment, and apparatus shall be made in an approved and permanent manner.

2.06 EXOTHERMIC WELDS

A. All exothermic welding shall be completed per welding kit manufacturer's instructions. Exothermic welds shall be CadWeld by Erico or ThermoWeld.

PART 3 -- EXECUTION

3.01 INSTALLATION

A. Metal surfaces where grounding connections are to be made shall be clean and dry. Steel surfaces shall be ground or filed to remove all scale, rust, grease, and dirt. Copper and galvanized steel shall be cleaned with emery cloth to remove oxide before making connections.

B. Ground Grid

1. A main ground grid shall be provided for each structure and interconnecting structure grids consisting of driven ground rods as shown on the Drawings. The ground rods shall be interconnected by the use of copper cable exothermically welded to the rods. The grounding cables shall be installed after the excavations for the building have been completed and prior to the pouring of concrete for the footings, mats, etc. Copper "pigtails" shall be exothermically welded to the ground grid and shall enter the buildings and structure from the outside and shall be connected to steel structures, and equipment as described in this Section and as required to provide a complete grounding system.

2. Grounding conductors shall be continuous between points of connection; splices shall not be permitted.

3. Where conductors are exposed and subject to damage from personnel, traffic, etc., conductors shall be installed in metal raceway. The raceway shall be bonded to the grounding system.

4. Where subsurface conditions do not permit use of driven ground rods to obtain proper ground resistance, rods shall be installed in a trench or plate electrodes shall be provided, as applicable and necessary to obtain proper values of resistance.

C. Raceways

1. Conduit which enters equipment such as switchgear, motor control centers, transformers, panelboards, variable frequency drives, instrument and control panels, and similar equipment shall be bonded to the ground bus or ground lug, where provided, and as otherwise required by the NEC.

3.02 TESTING

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

1. Witnessed Shop Tests

a. None required.

2. Field Tests

a. Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 1, and NETA acceptance testing specifications referenced in Section 16000, Basic Electrical Requirements.

b. Provide 48 hours notice to the Owner and Engineer prior to testing. DO NOT CONNECT TO UTILITY PRIOR TO TESTS AND DO NOT BACKFILL BURIED EXOTHERMIC WELDS OR GROUND-RING PRIOR TO FIELD INSPECTION BY THE ENGINEER.

c. Fall of potential tests shall be performed on the ground grid per IEEE81 recommendations by a third party, independent testing firm. A fall of potential plot shall be submitted at the conclusion of testing for Engineer review. Documentation indicating the location of the rod and grounding system as well as the resistance and soil conditions at the time the measurements were made shall be submitted. Testing shall show that the ground grid has 5 ohms resistance or less. Due to soil conditions and/or unforeseen field conditions, ground resistances greater than 5 ohms may be acceptable if specifically approved in writing by the Engineer. Ground resistance measurements shall be made in normally dry weather not less than 48 hours after rainfall and with the ground grid under test isolated from other grounds.

d. Continuity tests for the grounding electrode conductor shall also be performed. Test will be accepted when a resistance of less than 1 ohm is shown for this conductor.

- END OF SECTION -

SECTION 16190

SUPPORTING DEVICES

## PART 1 -- GENERAL

### 1.01 THE REQUIREMENT

A. The Contractor shall furnish and install structural stainless steel supports for mounting and installing all electrical, lighting, alarm systems, instrumentation, and communications equipment furnished under this Contract.

B. Equipment shall be installed strictly in accordance with recommendations of the manufacturer and best practices of the trade resulting in a complete, operable, and safe installation. The Contractor shall obtain written installation manuals from the equipment manufacturer prior to installation.

C. Reference Section 16000, Basic Electrical Requirements.

### 1.02 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the Contractor shall obtain from the equipment manufacturer and submit shop drawings. Each submittal shall be identified by the applicable Specification section.

### 1.03 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. Product data sheets.

2. Complete assembly, layout, installation, and foundation drawings with clearly marked dimensions.

## PART 2 -- PRODUCTS

### 2.01 MANUFACTURERS

A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed,

constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

2.02 MATERIALS

A. Materials used in accordance with this Section shall be as specified herein.

PART 3 -- EXECUTION

3.01 INSTALLATION

A. Concrete or Masonry Inserts

1. The Contractor shall be responsible for the furnishing and installation of all conduit sleeves, anchor bolts, masonry inserts, and similar devices required for installation of equipment furnished under this Contract.

2. If a time delay for the arrival of any special inserts or equipment drawings, etc. occurs, the Contractor may, if permitted by the Engineer, make arrangements for providing approved recesses and openings in the concrete or masonry and, upon subsequent installation, the Contractor shall be responsible for filling in such recesses and openings. Any additional costs that may be incurred by this procedure shall be borne by the Contractor.

B. Support Fastening and Locations

1. All equipment fastenings to columns, steel beams, and trusses shall be by beam clamps or welded. No holes shall be drilled in the steel. Where supports or hangers are required for heavy electrical equipment units exceeding fifty pounds, a proposed support detail shall be submitted to the Engineer for review and approval . Where required, additional sections shall be provided for a safe installation. Supports and hangers shall be stainless steel as required to suit the application and shall be compatible with the balance of the installation.

2. For outdoor service, the support system shall be made of Type 304 stainless steel. The materials of construction shall be coordinated with the process/chemical area in which the support system will be installed. All equipment, devices, and raceways that are installed on the dry side of a water bearing wall shall not be installed directly onto the wall. Nominal 1-5/8” x 3/4” (minimum) channel shall be used to allow ventilation air to pass behind the equipment, devices, or raceway.

3. All hardware (bolts, nuts, washers, etc.), regardless of installation location, shall be Type 304 stainless steel.

4. All supports shall be rigidly bolted together and braced to make a substantial supporting framework. Where possible, control equipment shall be grouped together and mounted on a single framework. Wherever this occurs, a provision shall be made for ready access to the wiring for connections to the equipment by means of boxes with screw covers.

5. Actual designs for supporting framework should take the nature of a picture frame of channels and bracket with a plate for mounting the components. The Contractor is responsible for the design of supporting structure; he shall submit design details to the Engineer for acceptance before proceeding with the fabrication.

6. Wherever dissimilar metals come into contact, the Contractor shall isolate these metals as required with neoprene washers, nine (9) mil polyethylene tape, or gaskets.

- END OF SECTION -

SECTION 16195

ELECTRICAL - IDENTIFICATION

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. All electrical equipment shall be properly identified in accordance with these Specifications and the Contract Drawings. All lighting and distribution panelboards, control panels, pull/junction boxes, enclosures, control stations, and similar equipment shall be identified in the manner described, or in an equally approved manner.

B. The types of electrical identification specified in this section include, but are not limited to, the following:

1. Operational instructions and warnings.

2. Danger signs.

3. Equipment/system identification signs.

4. Nameplates.

1.02 SIGNS

A. "DANGER-HIGH-VOLTAGE" signs shall be securely mounted near the electrical equipment lineup and on the generator enclosure.

1.03 LETTERING AND GRAPHICS

A. The Contractor shall coordinate names, abbreviations, and other designations used in the electrical identification work with the corresponding designations shown, specified or scheduled. Provide numbers, lettering, and wording as indicated or, if not otherwise indicated, as recommended by manufacturers or as required for proper identification and operation/maintenance of the electrical systems and equipment.

1.04 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the Contractor shall obtain from the equipment manufacturer and submit shop drawings. Each submittal shall be identified by the applicable specification section.

1.05 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

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B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. Product data sheets.

## PART 2 -- PRODUCTS

### 2.01 MANUFACTURERS

A. The material covered by these Specifications is intended to be standard material of proven performance as manufactured by reputable concerns. Material shall be fabricated, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as specified herein and shown on the Drawings.

### 2.02 NAMEPLATES

A. Manufacturers:
1. Port Plastics.
2. Brady.
3. Seton.
4. Electromark.
5. Substitutions: Section 01600 - Product Requirements.

B. Product Description: Laminated three-layer plastic with engraved white letters on black contrasting background color.

C. Letter Size:
1. ¼ inch high letters for identifying individual smaller equipment, junction boxes, and instruments, etc.
2. ½ inch high letters for identifying grouped equipment and loads, and lighting panelboards, lighting contactors, dry-type transformers and switches 200 Amps and under, etc.
3. 1 inch high letters for identifying large electrical components such as motor control centers, power panelboards, packaged HVAC equipment, switches over 200 Amps, etc.

D. Minimum nameplate thickness: 1/8 inch.

### 2.03 HIGH VOLTAGE SIGNS

A. Standard "DANGER" signs shall be of baked enamel finish on 20 gage steel; of standard red, black and white graphics; 14 inches by 10 inches size except where 10 inches by 7 inches is the largest size which can be applied where needed, and except where a larger size is needed for adequate identification.

2.04 CONDUIT IDENTIFICATION

A. Conduit identification shall be as specified in Section 16111, Conduit.

2.05 WIRE AND CABLE IDENTIFICATION

A. Field installed wire and cable identification shall be as specified in Section 16123, Building Wire and Cable.

B. Wiring identification for factory installed wiring in equipment enclosures shall be as specified in the respective section.

PART 3 -- EXECUTION

3.01 NAMEPLATES

A. Nameplates shall be attached to the equipment enclosures with (2) two stainless steel sheet metal screws for nameplates up to 2-inches wide. For nameplates over 2-inches wide, four (4) stainless steel sheet metal screws shall be used, one (1) in each corner of the nameplate. The utilization of adhesives is not permitted.

3.02 OPERATIONAL IDENTIFICATION AND WARNINGS

A. Wherever reasonably required to ensure safe and efficient operation and maintenance of the electrical systems and electrically connected mechanical systems and general systems and equipment, including prevention of misuse of electrical facilities by unauthorized personnel, install plastic signs or similar equivalent identification, instruction, or warnings on switches, outlets, and other controls, devices, and covers or electrical enclosures. Where detailed instructions or explanations are needed, provide plasticized tags with clearly written messages adequate for the intended purposes. Signs shall be attached as specified above for nameplates.

3.03 POWER SOURCE IDENTIFICATION

A. After installation of all field equipment (i.e. motors, instruments, etc) install nameplates at each power termination for the field equipment. Nameplate data shall include equipment designation (tag number), power source (panelboard, etc), circuit number, conduit number from schedule and voltage/phase.

B. Contractor to coordinate with the Engineer and the Owner regarding exact nameplate placement during construction.

C. Nameplates shall be as specified herein.

- END OF SECTION -

SECTION 016449

PUMP CONTROLS SYSTEM

## PART 1 -- GENERAL

### 1.01 SCOPE

A. Provide a complete Pump Control System for wastewater pump stations by monitoring liquid level in wet well using conductive sensing-type level probe input. For integration with the present BCWS supply system, the controller/RTU shall be the MultiTrode MultiSmart unit. The controller along with all electric power, SCADA radio with its associated components, and the level controls and its associated components are located inside the Pump Control Panel.

B. The Pump Control Panel with all associated appurtenances constitutes the Pump Controls System. Refer to Sewer Panel section 3 of this specification for additional information.

C. The major Pump Control Panel components include: MultiSmart well level controller/RTU, SCADA Radio, Reduced Voltage Solid-State (RVSS) motor starters, shorting (bypass) and isolation contactors, protective relays, intrinsically safe relay, control relays, pushbuttons, 12-Volt DC power supply/battery charger, battery, control power transformer, terminals, circuit breakers, fuses, surge protective device, enclosure, wiring, wire-ways, and all other necessary appurtenances and associated materials lists as indicated on Sewer Panel Section 3 of this specification

D. Major components required in the complete pump control system are specified herein. Other components are not directly specified but are nonetheless required and shall be provided by the pump control panel fabricator as per the attached materials list on the pump control panel drawings. The panel fabricator shall provide a completely operational, prewired, pretested pump control system.

E. Panel Fabricator shall provide and install SCADA communications equipment that belongs inside the Pump Control Panel as recommended by the Communications Equipment supplier(s) identified in Section 1.3 below. The SCADA equipment is specified in Section 2.13 herein. The site Contractor shall provide and install remaining SCADA equipment (antenna, pole, coaxial cable, connectors, Path Study, system radio testing, grounding) that interfaces with the Pump Control Panel in accordance with project design drawings and manufacturer's recommendations. The SCADA system shall be complete in all regards, and functioning properly per BCWS acceptance.

F. The Pump Control System supplier shall purchase and install new, good quality materials to provide a completely functioning UL 698 or 698A listed system, as intended. Any materials in the material list in Sewer Panel 3J that could possibly jeopardize the panel's UL listing shall be substituted by the Pump Control Panel supplier/fabricator with UL acceptable products. The Contractor is responsible to immediately notify the Engineer of any and all changes to the materials list as a result of this requirement. Detailed justification shall be provided for each substituted part. BCWS and Engineer retain the right to reject or require other components be used per specifications at no additional cost to BCWS. Schedule delays caused by review of substituted parts in the Pump Control Panel are the responsibility of the Contractor.

1.02 SUBMITTALS

A. Section 01300 - Submittals.

B. Shop Drawings: Comply with NEMA ICS 1 and indicate control panel layouts, wiring connections and diagrams, dimensions, and support points. The layout shall exactly match BCWS' control panel drawing. Only BCWS-approved, justified changes are allowed and written approval is required prior to deviation from BCWS' control panel drawings. The Engineer will require 21 calendar days to review design deviations. Schedule for submittal review is the Contractor's responsibility.

C. The Pump Controls System supplier/fabricator shall provide to BCWS and the Engineer a completely "As-Built" set of drawings in ACAD format and in PDF format. Complete materials list, with manufacturer and part numbers shall be included. Drawings and Materials Lists shall be provided on read/write CDs, three (3) copies are required.

D. Product Data: Submit catalog data for each component showing electrical characteristics, physical dimensions and connection requirements. Product Data for components may be provided as PDF catalog cut-sheets on CD, or neatly bound and tabbed in 3-ring binders with table of contents. All component selections shall be highlighted or otherwise outlined to indicate to the Engineer and BCWS which components are selected. If proper marking has not been done, the submittal will be returned to the Contractor without comments and will be unequivocally rejected.

E. Materials used shall be as per the attached material lists at the back of this specification section. "Or-equal" substituted components shall be noted in the panel fabricator's submittal with complete information required in paragraph C above. Only pre-approved substitute parts will be allowed. Any parts substituted that are unapproved will result in panel rejection at the

Contractors' expense. However, the Pump Controls System provider is encouraged to submit better-performing products and/or improved design ideas for review at the proper time.

PART 2 -- PRODUCTS

2.01 PUMP CONTROL SYSTEM OVERVIEW

A. System Requirements: The controller used for this project shall be the MultiTrode MultiSmart Model MSU3MP advanced microprocessor based pump controller, No exception. Standardization of pump control panel design and interchangeability of parts necessitate this fact. The following major equipment items compatible components shall be used:

1. Level Controller: MultiTrode MSU3MP with included Motor Protection Monitoring Module, RTU and Flow Monitoring Function.

2. Level Probe: Multitrode or MPE, 10 12 inch segments, 3 meter (approximately 10 ft) conductive sensing probe. VFD stations will require an ultrasonic level sensing unit for speed control. Flygt LSU100 or Pulsar DBI no substitutions. The probe will be installed as back up.

3. Intrinsically Safe Barrier: Multitrode Model MTISB-10 or MPE ISB10.

4. I/O Extension Module: Adams Model 6051.

B. The Pump Control Panel shall be provided with a main circuit breaker with handle operator. All circuit breaker handle operators shall properly fit respective circuit breakers and shall not impede swing-out door operation. Improperly fitted circuit breaker extension handles, or any problems caused by the circuit breaker handles shall be repaired by the Contractor at his expense and at no additional cost to BCWS.

C. Motor protection:

1. The MultiTrode MSU3MP pump controller shall be used to provide advanced motor protection and data analysis of the system performance as well as integration with SCADA system. The SCADA system is specified in Section 2.13, herein.

2. Individual RVSS motor starters shall be supplied with a properly sized, line-side, thermal magnetic-type circuit breaker to provide short circuit and ground fault overcurrent protection and act as a disconnecting means. Refer to paragraph 2.8, Motor Starters, below. In pump control panel, auxiliary contact on circuit breaker disconnecting means generates alarm to the MultiSmart controller when in the OFF position. Each motor shall be provided with an isolation contactor sized per motor nameplate FLA, meeting requirements of NEC 430.32 and these specifications. Reset Push Buttons will be located on the on the inner door and will reset the RVSS fault conditions.

3. For panels serving submersible pumps, each pump motor shall be wired to an electrode relay providing high probe potential for the leak detection system built into the oil filled motor shaft housing. The electrodes will activate if moisture content in the oil sealed area reaches abnormal levels. Electrode activation shall open the control circuit to the pump motor starter preventing possible damage to the pump motor from water ingestion. Pump will be placed out of service until maintenance is performed on the unit and control system reset.

4. For panels serving aboveground suction-lift pumps, provide suitable provisions for motor protection per C.1 and C.2, above.

D. Enclosure: See Section 2.8 herein. All required equipment shall be installed inside a stainless steel enclosure equipped with a subpanel and interior swing open dead front door. The Enclosure is located in a non-hazardous but corrosive location, outdoors exposed to weather. Circuits originating from enclosure extend into an NFPA-820 and NEC rated C1 D2 Group D hazardous (classified) area. Separate all wiring for intrinsically safe circuitry in accordance with NEC Article 504.

E. System Voltage Protection: Transient Voltage Surge Suppressor (TVSS) or surge protective device shall be provided, prewired inside the enclosure. The UL 1449, 2nd Ed., surge protective device (SPD) shall provide 4-mode, line- voltage surge protection for the control panel incoming power supply. The SPD shall have a minimum surge rating of 200kA/phase, with each phase having its own status indicator. Surge current modes are Line to Neutral, Line to Ground, Neutral to Ground, and Line to Line, and each mode shall have a minimum of 100kA/phase protection. The TVSS shall be provided with a line- side, manual disconnecting switch inside the panel to simultaneously disconnect all ungrounded conductors for maintenance. Lead lengths shall be as short as possible

F. Backup power supplies: Provide a 12 Volt DC supply inside Pump Control Panel for the SCADA Radio system. The system shall accept 120 VAC input voltage and consist of a DC power supply/charger, and battery:

1. The 12 Volt DC power supply/ charger shall be 55 Watts, minimum, with automatic reset for over currents. Output current 0-4 Amps; ± 0.5% load regulation, ± 1% output voltage is nominal 13.8 VDC with regulation 100 mV Peak-peak ripple. The charger shall be integral with power supply.

2. The 12 Volt DC rechargeable battery shall be SLA, 12 Ah, with nut and bolt, or spade lug terminations.

G. Remote Alarm Reporting - The Pump Control Panel shall report alarms remotely via the SCADA system. Alarms shall be reported through SCADA for any of the following reasons:

1. Multitrode Probe indicates a high water level in wet well.

2. The moisture detection system indicates moisture in the oil chamber between the motor seals.

3. The motor winding temp switches indicate high motor temperature caused by improper motor cooling or motor overload.

4. Overload protective devices in motor controls circuit indicate motor overload.

5. Electrical failure detected by the power failure control relay, or by the phase monitor.

6. RVSS failure.

7. Motor branch circuit breaker disconnecting device left in "off" position.

8. Other alarm events as shown on the pump control panel drawings.

H. Wiring:

1. Control wire shall be MTW, 90 degree C, #14 AWG, stranded copper. Signal wiring may be #16 AWG.

2. All wiring should be neatly grouped in plastic wire trough except wiring from the backplate to the door shall be done in separate bundled harnesses.

3. All wires shall have a wraparound wire identification number as shown in the wiring diagram at both ends.

4. All components shall be identified with the same number as shown in the control panel schematic drawings.

2.02 CONTROL SWITCHES AND STATIONS

A. Manufacturers:

1. ABB.

2. Siemens

3. Eaton/Cutler-Hammer.

4. Square D.

5. Substitutions: Permitted if approved by BCWS

B. Product Description: NEMA ICS 5, heavy-duty, corrosion resistant devices.

C. Contacts: Form Z, or as required by control panel drawings.

D. Contact Ratings: Class A600.

E. Pushbutton Operator: Non-illuminated, momentary contact, flush type. Use pushbuttons listed as suitable for outdoors, weather-exposed applications.

2.03 MAGNETIC CONTROL RELAYS

A. Manufacturers:
1. ABB
2. Siemens
3. Eaton/Cutler-Hammer
4. Square D.
5. G.E.
6. Substitutions: Permitted if approved by BCWS

B. Product Description: NEMA ICS 5, Class A300 magnetic control relay. Relays shall have industry standard wiring and pin arrangements. Control relay coils shall be equipped with appropriate voltage-transient protection.

C. Contacts: Form C, or as selected by panel fabricator.

D. Contact Ratings: Class A150, minimum

E. Coil Voltage: 120 Volts, 60Hz. AC; or 12 Volts DC, or as required on drawings.

F. Enclosure: NEMA ICS 6, Type to meet conditions of installation.

2.04 SOLID-STATE CONTROL RELAYS

A. Manufacturers:
1. ABB.
2. Siemens
3. Eaton/Cutler-Hammer.
4. Square D.
5. G.E.
6. Substitutions: Permitted if approved by BCWS

B. Product Description: NEMA ICS 5, solid-state electronic relay.

C. Contacts: Form C. or as selected by panel fabricator.

D. Contact Ratings: Class A150, minimum.

E. Coil Voltage: 120 60 Hz. AC, or 12 Volts DC, or as required on drawings.

F. Listing: UL Listed.

2.05 TIME DELAY RELAYS

A. Manufacturers:
1. Diversified electronics
2. Artisan.
3. Siemens
4. Eaton/Cutler-Hammer
5. Square D.
6. Idec.
7. Substitutions: Permitted if approved by BCWS

B. Product Description: NEMA ICS 5, solid state, sealed switch timing relay. Unit is an initiate switch controlled, delay-on-break timer operating a set of contacts. Select optional timer settings as indicated on drawings.

C. Contacts: NEMA B600, 600VAC, 5 Amps.

D. Coil Voltage: 120 Volts, 60 Hz AC, or 12 Volts DC, as required on drawings.

E. Listing: UL Listed.

2.06 LEVEL PROBE

A. Manufacturers:
1. Multitrode
2. MPE
3. Substitutions: Not Permitted.

B. Probe Model Number: 3.0/10-33 or 115-10-50. 10ea 12 inch zones unless approved by BCWS.

C. Mounting Kit: provide and install matching integral cleaning and mounting bracket with all appurtenances. Hardware is stainless steel.

2.07 MOTOR STARTERS- RVSS/VFD

A. Manufacturers:
1. ABB.
2. Siemens
3. Square D. – Design basis is Altistart 48, Y-range, Soft-Start Controller. For Under 20Hp Altistart 22 are acceptable
4. Yaskawa
5. Substitutions: Not Permitted.

B. Reduced Voltage, Solid State Soft-Starters (RVSS): For motors above 7.5 HP.

1. Provide a microprocessor controlled, RVSS for NEMA Design B type, squirrel cage, 3-phase induction motors that meets the following requirements.

2. The electronic "soft starter" shall be UL listed.

3. The manufacturer shall be a certified ISO 9002 facility.

4. The soft starter shall utilize an SCR, or IGBT bridge consisting of at least two power-electronic switches per phase to control the starting and stopping of industry standard motors. It shall provide torque control for linear acceleration independent of motor load or application type without external feedback. The gating of the devices will be controlled in such a manner to ensure stable and linear acceleration ramp.

5. The use of a shorting (or bypass) contactor on-board control relay shall be a standard on soft starters. Protective features and deceleration control options integral to the soft starter shall be available even when the shorting contactor is engaged.

6. The allowed shorting / bypass contactor sizes shall be based upon NEMA ratings, without exceptions. Refer to the table below for motor starter contactor sizes.

C. VFD (Variable Frequency Drives)

1. Will be required for flow pacing, stations that share force mains, and for single phase to three phase conversions. These are not typical designs and must be addressed on a case by case basis with BCWS approval.

**Table of Motor Contactor Sizes**

| Motor HP | Motor Voltages | Phase | NEMA shorting Contactor Size | Starter Continuous Amp Rating |
|---|---|---|---|---|
| 7.5 | 230 V | 1ø * | 2 | 45 |
| 7.5 | 230 V | 3ø | 1 | 27 |
| 7.5 | 460 V | 3ø | 1 | 27 |
| 10 | 230 V | 3ø | 2 | 45 |
| 10 | 460 V | 3ø | 1 | 27 |
| 15 | 230 V | 3ø | 2 | 45 |
| 15 | 460 V | 3ø | 2 | 45 |
| 20 | 230 V | 3ø | 3 | 90 |
| 20 | 460 V | 3ø | 2 | 45 |
| 25 | 230 V | 3ø | 3 | 90 |
| 25 | 460 V | 3ø | 2 | 45 |
| 30 | 230 V | 3ø | 4 | 135 |
| 30 | 460 V | 3ø | 3 | 90 |
| 40 | 230 V | 3ø | 4 | 135 |
| 40 | 460 V | 3ø | 3 | 90 |
| 50 | 230 V | 3ø | 5 | 270 |
| 50 | 460 V | 3ø | 4 | 135 |
| 60 | 230 V | 3ø | 5 | 270 |
| 60 | 460 V | 3ø | 4 | 135 |
| 75 | 230 V | 3ø | 5 | 270 |
| 75 | 460 V | 3ø | 4 | 135 |
| 100 | 230 V | 3ø | 6 | 540 |
| 100 | 460 V | 3ø | 5 | 270 |
| 125 | 230 V | 3ø | 6 | 540 |
| 125 | 460 V | 3ø | 5 | 270 |

* On 1ø stations, VFD will be used to convert to 3ø.

2. Contactors shall have continuous current ratings based upon NEMA standards. IEC contactors shall meet or exceed the NEMA starter continuous current ratings above for a particular size to be allowed.
3. RVSS Ratings shall be as follows:

   a. The soft start shall be designed to operate in an ambient temperature 0□C to 40□C (14□F to 104□F). For ambient temperatures between 40□C and 60□C (104□F and 140□F), derate the current by 2% per □C above 40□C (104□F).

   b. Storage temperature range shall be -25□C to 70□C (-13□F to 158□F).

c. Maximum relative humidity shall be 95%, non-condensing or dripping water, conforming to IEC 60947-4-2

d. The soft starter shall be designed to operate in altitudes up to 3300 ft.

e. The soft starter shall be capable of operation between + / - 10% of nominal voltage rating.

f. The soft start shall automatically adapt for operation at 50 or 60 Hz, with a frequency tolerance of +/- 5%. By configuration, it will have to be capable of operation at a supply line frequency that can vary by +/- 20% during steady state operation.

g. The soft start shall be capable of supplying 400% of rated full load current for 23 seconds at maximum ambient temperature. The soft starter shall also be capable of 10 evenly spaced starts per hour at 400% of full rated current for 12 seconds per start.

h. The SCRs shall have a minimum P.I.V. rating of 1800 Volts AC. Lower rated SCRs with MOV protection are not acceptable.

4. All programming/configuration devices, display units, and field control wiring terminals shall be accessible on the front of the control module. Exposure to control circuit boards or electrical power devices during routine adjustments is prohibited.

5. Digital indication shall provide status on the RVSS, faults, and the motor.

6. RVSS shall have factory preset operational features for normal conditions. Parameters shall be field adjustable through the digital keypad. Motor FLA, starting current limits, linear acceleration ramps, torque adjustments, torque limits, starting time, voltage boost for starting, braking selections, deceleration ramps, braking torque and overload class selections shall be included as field adjustable parameters, as a minimum.

7. RVSS Output relays shall include one (1) NO contact for fault indication, one (1) NO contact for indication that acceleration ramp is complete and current is below 130% of motor FLA, for end-of-start, and one (1) programmable NO contact.

8. Additional RVSS I/O shall be provided as required on the project design drawings as a minimum. Provide two assignable control inputs for the force to freewheel stop, external fault input, disable serial link control, external motor overload reset or general fault reset. Include two assignable logic-level signal outputs for motor thermal overload alarm, “motor powered” signal, motor overcurrent alarm, or motor underload alarm. Include one analog output for 4 to 20 milliamp

indication of motor speed or motor current.

9. Protection - A microprocessor-based motor thermal protection system shall be included which continuously calculates the temperature-rise of the motor and soft starter and provides a motor overload pre-alarm that indicates by relay contact or logic output that the motor windings have exceeded 130% of its rated temperature rise. This function shall be for alarm only. A motor overload fault will stop the motor if the windings have exceeded 140% of temperature-rise. The soft starter shall provide line and motor phase loss, phase reversal, underload, stall, and jam protection. The integral protective features shall be active even when the shorting contactor is used to bypass the SCRs during steady state operation.

10. Communications – To directly connect the RVSS to Modbus, the soft starter will have to include a serial link. The soft starter shall be able to be connected to Ethernet and other networks, with connection to the communication bus as an option. The communication shall be able to provide access to the control, to the adjustment and to the supervision of the soft starter.

11. Shorting / Bypass Contactor - A microprocessor shall control the operation of the shorting contactor via an output relay. The shorting contactor shall close, shorting the SCRs after the acceleration ramp is compete and motor current is below 130% of motor FLA, and open on a stop command to allow a deceleration ramp. Overload protection integral to the soft starter shall continue to protect the motor when shorting is engaged as stated in paragraphs 5 and 6 above.

12. Isolation contactor – A NEMA rated isolation contactor is required between the RVSS and the motor so that the IRT function of the Multismart may be utilized

13. Cabinet Cooling in the form of a stainless steel heat exchanger will be required on control panels utilizing an RVSS. Cabinets containing a VFD will require a stainless steel air conditioning unit

2.08 CONTROL PANEL ENCLOSURES

A. Manufacturers:
   1. Saginaw.
   2. B-Line.
   3. Hoffman. – Design basis Enclosure and Air Conditioning unit.
   4. EMF.
   5. Substitutions: per Section 01300.

B. Product Description: Cabinet conforming to NEMA ICS 6, Type 4X, 304 or 316 stainless steel powder coated white – no exceptions. The NEMA rating may be reduced to 3R based upon installation of the Air Conditioner unit and the 3-point, 90 degree turn lockable latch kits that are required on this panel. Panel shall have a hinged, interior door to provide mounting surface for controller displays, labels, and other required components.

C. Pump Control Panel Minimum Size: All pump control panels over 30 HP shall be free-standing, with the panel firmly secured to the finished floor. The minimum allowed free-standing enclosure size shall be 74x60x24 (inches). Triplex stations may be equipped with two (2) side by side free-standing enclosures; however, both enclosures will require separate air conditioners. Accessory feet kits shall be provided with adequate clearance from finished floor such that sufficient space is included to install conduit stub-ups from underground and their associated sealing fittings and hardware and hubs.

D. Equipment racks will be required for additional appurtenances such as the ATS, transformer, weatherproof receptacle, LED light, and mini power zone as required. Racks will be of welded aluminum and structurally capable of supporting the equipment. Racks may be on or two sided with the control panel facing the wet well and the ATS facing the generator.

E. Shop-fabricate the Pump Control Panel to NEMA ICS 1.

F. Box Size: as required to meet project requirements. Ensure adequate wiring space is provided, and thermal/air flow needs of various components are considered in sizing of enclosure. RVSS usage will require a stainless steel heat exchanger. VFD usage will require a stainless steel air conditioner.

G. Fronts: 304 or 316 stainless steel, fully gasketed, dead-front, surface mounted type with 3-point, quarter-turn latching, lockable door handle with concealed hinge. Hinges shall be completely rust-free under all circumstances. Enclosures, hinges or hardware that rusts, including “surface” rust where pitting is evident, shall cause the entire panel be replaced and any and all associated repair work and materials shall be at the Contractors’ expense and at no additional costs to BCWS. Finish: manufacturer’s standard.

H. Knockouts: performed by field Contractor.

I. Furnish grounded metallic or other acceptable barriers to form separate compartments for wiring of different systems and voltages. Isolate Intrinsically Safe equipment per NEC Art. 504.

## 2.09 TERMINAL BLOCKS

A. Manufacturers:
1. ABB.
2. Cooper.
3. Eaton/Cutler-Hammer.
4. Square D.
5. G.E.

6. Substitutions: Permitted with BCWS approval

B. Product Description: NEMA ICS 4, terminal blocks.

C. Power Terminals: Unit construction type with closed back and tubular pressure screw connectors, rated 600 Volts. Suitable for use with copper wire.

D. Signal and Control Terminals: Modular construction type, suitable for channel mounting, with tubular pressure screw connectors, rated 600 Volts. Suitable for use with copper wire.

E. Include ground bus terminal block, with each connector bonded to enclosure.

F. Terminals shall be properly secured to sub-panel or din rails. If conductors are causing terminals to become stressed by over tension, or improper bending space or any other reasons causing the terminals to bend, deform, or become over-burdened, the Contractor shall make repairs at his expense, at no additional cost to BCWS.

## 2.10 PLASTIC RACEWAY

A. Manufacturers:
1. ABB.
2. Panduit.
3. Hoffman.
4. Thomas&Betts.
5. Substitutions: Permitted as required by panel fabricator.

B. Product Description: Plastic channel with hinged or snap-on cover.

## 2.11 SCADA COMMUNICATIONS EQUIPMENT

A. Required Equipment:

1. Radio. Cal Amp Viper model 140-5048-502 or as required by BCWS.

2. Antenna. Laird Y(B)4506 450-480 MHz frequency operation or as required by BCWS.

3. Coaxial Cable. Commscope FSJ4-50B or equivalent

4. Jumper inside panel Commscope RG142-TNMNM-3M or equivalent

5. Surge suppressor. Polyphaser IS-B50LN-C2

6. Coaxial Grounding Kit and miscellaneous appurtenances.

7. Path Study shall be performed by the SCADA Subcontractor after consultation with the Contractor. Schedule of Path Studies shall be provided to the Engineer and BCWS 30 days prior to actual study.

8. Substitutions: Permitted as required by BCWS and SCADA equipment supplier.

B. System Description:

1. All control signals, status signals, alarm and or process variable data generated by the RTU shall be transmitted and received between the central location and the remote site via the SCADA radio communication system. Ensure that Radio Communication of Charleston performs a path study between remote pump station locations and repeaters or master stations as required.

2. The RTU is the Multitrode Multismart Controller with DNP3, flow calculation, logic engine, and ADAMS I/O expansion. The RTU provides signal input to the Radio. Power input to the Radio comes from the 12 VDC power supply unit that is in the Pump Control Panel described in 2.1, G, above.

3. Radio output is transmitted via a coaxial cable to the antenna. The Antenna shall be mounted by Contractor. All coaxial connections or terminations are to be made per the manufacturer's recommendations. Any damaged components, cable, or high losses found or discovered through testing will be repaired by the Contractor at no additional cost to BCWS.

4. Any additional components, testing, or required equipment for a completely operational SCADA radio communications shall be provided by the Contractor at no additional costs to BCWS.

C. SCADA System Assembly

1. The radio, coax surge suppressor, 6 ft. coaxial cable jumper, communications connectors and any other radio required hardware shall be provided to the Pump Control Panel fabricator for installation in the Panel. System shall be completely integrated.

2. Antenna, feed-line coaxial cable, coaxial cable supporting PVC or Nylon insulated straps (to secure coaxial cable to wood pole) and the raceway (heliax) cable bonding/grounding kit shall be provided by RCC to Contractor for installation.

3. Contractor shall install antenna, upper connector and waterproof kit, heliax and grounding/bonding kit in accordance with the scope of work. Additionally, the wood antenna pole, all raceway and raceway supports shall be provided and installed by the Contractor. The contractor will make sure the radio installation is

fully functional.

## PART 3 -- EXECUTION

### 3.01 EXISTING WORK

A. Where necessary, disconnect and remove abandoned controls and relays remaining at job site. Maintain station electrical service and control at all times except for switchover to new controls. Coordinate with BCWS prior to switchover.

B. Where existing equipment is present, dispose of equipment / materials as directed by BCWS.

C. BCWS may elect to salvage certain equipment. If BCWS decides to salvage any equipment, wiring or materials, it shall be returned to BCWS cleaned and in an undamaged condition. Coordinate with BCWS for a location to store or stage salvaged materials.

### 3.02 INSTALLATION

A. Install the assembled and pre-tested pump control panel on the electrical equipment rack, or bolt down to the concrete pad if free-standing, as shown on the project design drawings.

B. Install enclosures and boxes plumb.

C. Make electrical wiring interconnections as indicated on Drawings, and as otherwise required for a completely functioning control system.

D. Install engraved plastic nameplates.

E. Ground and bond control panels, raceway, and Intrinsically Safe barriers and relays.

F. Conduits entering the control panel from the wet well must be sealed in accordance with NEC Article 500, Class 1, Group D Specifications Separate wiring for intrinsically safe circuits for the level probe per NEC 504.

G. Clean the enclosure completely, vacuum out any wire strippings, clippings or metallic filings that may be found. Use manufacturer recommended cleaning agents. Improperly cleaned cabinets are cause for rejection of construction work.

H. Digital I/O will be located in accordance to the standard Multismart triplex diagram and the BCWS standard input diagram for all pump station configurations. In duplex stations all of pump 3 I/O will be unused - No Exceptions

I. Standard BCWS I/O

| INPUT NAME | INPUT NAME | MULTISMART | ADAM 6051 |
|---|---|---|---|
| Pump 1 Thermal | Flygt Seal | DI 12 | |
| ABS Seal | | DI 13 | |
| Thermal Overload P1 | Pump 1 Breaker | DI 14 | |
| Pump 2 Thermal | Flygt Seal | DI 15 | |
| ABS Seal | | DI 16 | |
| Thermal Overload P2 | Pump 2 Breaker | DI 17 | |
| Pump 3 Thermal | Flygt Seal | DI 18 | |
| ABS Seal | | DI 19 | |
| Thermal Overload P3 | Pump 3 Breaker | DI 20 | |
| Ultrasonic Level | Level Control | AI1 | |
| Flowmeter Rate | | AI2 | |
| Main Breaker Tripped/Off | | | DI 0 |
| Gernerator Run | | | DI 1 |
| Generator Fail | | | DI 2 |
| Pump 1 VFD/SSS Fault | Low Level Float (where required) | | DI 3 |
| Pump 2 VFD/SSS Fault | Low Level Float (where required) | | DI 4 |
| Pump 3 VFD/SSS Fault | Low Level Float (where required) | | DI 5 |
| Utility Power Fail | | | DI 6 |
| | | | DI 7 |
| | | | DI 8 |
| | | | DI 9 |
| Flowmeter | | | DI 10 |
| Rain Gauge | | | DI 11 |

Column A and B are wired in parallel

***Adam Module Inputs DI 7, DI 8, DI 9 are spare inputs***

- END OF SECTION -

SECTION 16476

ENCLOSED CIRCUIT BREAKERS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish and install enclosed circuit breakers of voltage and current ratings as specified herein and indicated on the Drawings.

B. This specification is intended to apply to circuit breakers separately-mounted from other equipment in an individual enclosure. This Section does not apply to circuit breaker as part of an equipment assembly such as motor control centers, panelboards, switchboards, etc.

C. Reference Section 16000, Basic Electrical Requirements.

1.02 STANDARDS

A. Enclosed circuit breakers shall conform to all applicable UL and NEMA standards. Materials and components shall be new and conform to grades, qualities and standards as specified herein and shown on the Drawings.

B. Enclosed circuit breakers shall comply with the following industry standards:

1. Underwriters Laboratories, Inc., Standard UL489, Molded Case Circuit Breakers and Circuit Breaker Enclosures

2. National Electrical Manufacturers Association Standards Publication No. AB1-1993, Molded Case Circuit Breakers

3. National Electrical Code

1.03 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the Contractor shall obtain from the equipment manufacturer and submit the following:

1. Shop Drawings.

2. Operation and Maintenance Manuals.

B. Each submittal shall be identified by the applicable specification section.

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1.04 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. Product data sheets.

2. Complete assembly, layout, and installation drawings with clearly marked dimensions for each enclosed circuit breaker.

D. Nameplate schedule for each enclosed circuit breaker.

1.05 IDENTIFICATION

A. Each enclosed circuit breaker shall be identified with the identification number indicated on the Drawings. A nameplate shall be securely affixed in a conspicuous place on the front of each enclosed circuit breaker. Nameplates shall be as specified in Section 16195, Electrical - Identification.

PART 2 -- PRODUCTS

2.01 MANUFACTURERS

A. The Equipment shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

B. Enclosed circuit breakers shall be manufactured by Cutler-Hammer, the General Electric Company, the Square D Company, or Siemens Energy and Automation, Inc.

2.02 ENCLOSED CIRCUIT BREAKERS

A. Circuit breakers shall be molded case type with trip and frame ratings as indicated on the Drawings. Breakers shall have an interrupting rating of 42,000 amperes symmetrical at 480 VAC, unless otherwise indicated on the Drawings.

B. A molded case service entrance circuit breaker sized as indicated on the Drawings shall be installed as a load circuit interrupting and protection device. Circuit breaker shall be provided with adjustable long-time, short-time, instantaneous and ground fault settings. The circuit breaker shall be provided with an electronic trip unit with adjustable long-time, short-time, instantaneous, and ground fault settings. It shall operate both manually for normal operation and automatically for protection against overload or short circuits.

C. The molded case circuit-breakers described above shall be manufactured and tested in accordance with U.L. and NEMA AB1 standards. Their interrupting rating shall be suitable for the available fault current from the utility. All electrical ratings shall be suitable for the application.

D. The circuit breaker shall be mounted and oriented to provide NEC required working clearance.

E. Enclosed circuit breakers to be provided in all outdoor locations shall be in NEMA 4X Type 304 stainless steel enclosures.

F. Enclosed circuit breakers shall be quick-make, quick-break and with an interlocked cover which cannot be opened when the breaker is in the “ON” position and capable of being locked in the “OPEN” position.

G. An Underwriter's Laboratories, Inc. inspection label shall appear on the interior of the enclosure.

H. Enclosed circuit breakers shall be suitable for use as service entrance equipment where indicated on the Drawings and so labeled to suit the application.

## PART 3 -- EXECUTION

### 3.01 INSTALLATION

A. The enclosed circuit breaker shall be furnished and installed as shown on the Drawings and as recommended by the equipment manufacturer.

B. Enclosed circuit breakers shall be set true and plumb in locations as shown on the Drawings. The top of enclosure shall not exceed six (6) feet above finished floor elevation.

### 3.02 TESTING

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

1. Witnessed Shop Tests

   a. None required

2. Field Tests

   a. Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 1, and NETA Acceptance Testing Specifications, latest edition.

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- END OF SECTION -

SECTION 16481

INDIVIDUAL MOTOR CONTROLLERS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish and install separately mounted, individual motor controllers for 120 volt single phase, and 208 and 480 volt three phase motors as specified herein and indicated on the Drawings. Individual motor controllers specified in this Section include reduced voltage solid state starters (RVSS).

B. Reference Section 16000, Basic Electrical Requirements and Section 16902, Electric Controls and Relays.

1.02 TESTING

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

1. Witnessed Shop Tests

a. None required.

2. Field Tests

a. Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 1, and NETA acceptance testing specifications referenced in Section 16000, Basic Electrical Requirements.

1.03 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the Contractor shall obtain from the equipment manufacturer and submit the following:

1. Shop Drawings.

B. Each submittal shall be identified by the applicable specification section.

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1.04 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings shall include but not be limited to:

1. Product data sheets.

2. Complete layout and installation drawings with clearly marked dimensions for each type/size/rating of individual motor controller.

3. Custom wiring diagrams for each individual motor controller. Standard wiring diagrams that are not custom created by the manufacturer for the individual motor controllers for this project are not acceptable. One wiring diagram which is typical for an equipment group (e.g. pump) is not acceptable. Each wiring diagram shall include wire identification and terminal numbers. Indicate all devices, regardless of their physical location, on the diagrams. Identify on each respective wiring diagram specific equipment names and equipment numbers consistent with those indicated on the Drawings.

4. Bill of material list for each individual motor controller.

5. Nameplate schedule for each individual motor controller.

6. Manufacturer's installation instructions.

7. Time-current curves for each type and size protective device if requested by the Engineer.

8. Approximate total shipping weight of each RVSS.

D. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these Specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items that the Contractor intends to provide are acceptable and shall be submitted.

E. Prior to completion and final acceptance of the project, the Contractor shall furnish and install "as-built" wiring diagrams for individual motor controller. These final drawings shall be plastic laminated and securely placed inside each individual motor controller unit door and included in the O&M manuals.

1.05 OPERATION AND MAINTENANCE MANUALS

A. The Contractor shall submit operation and maintenance manuals in accordance with the procedures and requirements set forth in the General Conditions and Division 1.

**B. All list of all factory and field entered parameters shall be provided at the end of the project. List shall include all modifications made during the startup period, with documentation and a description of each parameter.**

1.06 TOOLS AND SUPPLIES

A. The equipment shall be furnished with all special tools necessary to disassemble, service, repair and adjust the equipment.

1.07 SERVICE OF MANUFACTURER'S REPRESENTATIVE

A. For all reduced voltage motor controllers, the Contractor shall provide the services of a qualified manufacturer's technical representative who shall adequately supervise the installation and testing of all equipment furnished under this Contract and instruct the Contractor's personnel and the Owner's operating personnel in its maintenance and operation as outlined elsewhere in Division 1. The services of the manufacturer's representative shall be provided for a period of not less than as follows:

1. One trip of one (1) working day during installation of the equipment for all RVSS's.

2. One trip of one (1) working day after acceptance of the equipment.

3. One trip of one (1) working day during the warranty period.

B. Any additional time required to achieve successful installation and operation shall be at the expense of the Contractor. The manufacturer's representative shall sign in and out at the office of the Engineer's Field Representative on each day he is at the project.

1.08 IDENTIFICATION

A. Each equipment item shall be identified with a nameplate. The nameplate shall be engraved indicating the circuit number and equipment name with which it is associated. Equipment identification shall be in accordance with Section 16195, Electrical - Identification.

1.09 TRAINING

A. The Contractor shall provide training for Owner personnel. Training shall be conducted by the manufacturer's factory trained specialists who shall instruct Owner personnel in operation and maintenance of all equipment provided under this Section.

PART 2 -- PRODUCTS

2.01 MANUFACTURERS

A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

B. Individual motor controllers specified in this section shall be as manufactured by ABB, the Square D Company, Siemens Energy and Automation, Inc., Yaskawa, or Toshiba.

2.02 REDUCED VOLTAGE SOLID STATE STARTER

A. The solid-state reduced-voltage starter shall be UL and CSA listed. The solid-state reduced-voltage starter shall be an integrated unit with power SCRs, logic board, an integral paralleling bypass contactor, and electronic overload relay enclosed in a single molded housing. The starter shall meet all applicable requirements of this Section and other sections in this Division.

B. **The RVSS shall be sized one standard size larger than the required RVSS rating associated with the motor nameplate full load current (for example a 90hp motor application shall be provided with a RVSS suitable for starting and operating a 100hp motor).**

C. The RVSS shall be suitable for the following environmental conditions:

1. Operating Temperature: 0-50 degrees C

2. Humidity: 0-95 percent non-condensing.

3. Altitude: up to 3,300 feet.

D. The RVSS shall be suitable for operation on a 480 VAC, 3-phase, 60 Hertz system.

E. The SCR-based power section shall consist of six (6) back-to-back SCRs and shall be rated for a minimum peak inverse voltage rating of 1400 volts PIV. Units using triacs or SCR/diode combinations are not acceptable. Resistor/capacitor snubber networks shall be used to prevent false firing of SCRs due to dv/dt effects.

F. The integral paralleling run bypass contactor shall energize when the motor reaches full speed and close/open under one (1) times motor current. The paralleling run bypass contactor shall utilize an intelligent coil controller to limit contact bounce and optimize coil voltage during varying system conditions.

G. The starter shall be provided with electronic overload protection as standard and shall be based on an inverse time-current algorithm. Overload protection shall be capable of being disabled during ramp start for long acceleration loads via the device keypad. Overload protection shall be adjusted via the device keypad and shall have a motor full load ampere adjustment from 30 to 100% of the maximum continuous ampere rating of the starter. The starter shall have selectable overload class setting of 5, 10, 20 or 30 via the device keypad. The starter shall be capable of either an electronic or mechanical reset after a fault. Units using bimetal or eutectic alloy overload relays are not acceptable. Overtemperature protection (on heat sink) shall be standard.

H. The starter shall provide protection against improper line-side phase rotation as standard. The starter shall stop the motor load if a line-side phase rotation other than A-B-C exists.

I. The starter shall provide protection against a phase loss or unbalance condition as standard. The starter shall stop the motor load if a 50% current differential between any two phases is encountered.

J. The starter shall provide protection against motor jam and motor stall conditions.

K. The starter shall be provided with a form C normally open (NO), normally closed (NC) contact that shall change state when a fault condition exists. The contacts shall be rated 60 VA (resistive load) and 20 VA (inductive load). In addition, a display on the device keypad shall indicate the type of fault (Overtemp, Phase Loss, Jam, Stall, Phase Reversal, or Overload).

L. The Human Interface Module (HIM) provided for the RVSS shall be the same as provided for the variable frequency drives.

M. Enclosed units shall include a thermal-magnetic circuit breaker or fusible disconnect switch with current limiting fuses for short-circuit protection and quick disconnect means. Input and output isolation contactors shall be furnished as indicated on the Drawings.

N. The complete starter assembly shall be rated per UL 508D for a minimum short circuit current rating (SCCR) of 42 kA.

O. The following accessories and spare parts shall be provided for each starter:

1. Surge suppressor mounted on the line side of the starter to clip the input line voltage.

2. Lug kits for both the line and load side of the starter.

3. One (1) user's manual for each frame size of starter.

4. One (1) spare 24VDC power supply for each size used.

P. The reduced voltage solid state starter shall be the Square D Altistart 48, ABB equivalent, Siemens equivalent, Yaskawa equivalent, or Toshiba equivalent. Schematic Drawings are based upon the Square D Altistart 48, Y-range. Use of equivalent listed manufacturer shall be at no additional cost to the Owner.

## PART 3 -- EXECUTION

### 3.01 INSTALLATION

A. All individual motor starters shall be installed as indicated on the Drawings and as recommended by the equipment manufacturer.

- END OF SECTION -

SECTION 16495

VARIABLE FREQUENCY DRIVE SYSTEMS

PART 1 -- GENERAL

1.01 THE REQUIREMENT

A. The Contractor shall furnish, install, connect, test and place in satisfactory operating condition all variable frequency drives (VFD's) as specified herein and indicated on the Drawings.

B. The Contractor is responsible for coordinating with the VFD manufacturer to ensure that the VFD is sized properly to meet all the requirements specified herein. The Contractor is responsible for including any costs related to electrical equipment upsizing, conduit and wire upsizing, and other items that result from selecting an alternate to the named pump manufacturers named in Section 11130.

C. The variable frequency drive system shall be assembled using NEMA rated components. Components designed and built to International Electrotechnical Commission (IEC) standards are not recognized. Equipment designed, manufactured, and labeled in compliance with IEC standards are not acceptable.

D. Reference Section 16000, Basic Electrical Requirements, Section 16902, Electric Controls and Relays.

1.02 TESTING

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

1. Shop Tests

a. The VFD's specified in this Section shall be shop tested and inspected in accordance with the equipment manufacturer's standard procedures. The testing and inspection procedures shall demonstrate that the equipment tested conforms to the requirements specified. The VFD manufacturer shall use standard testing procedures for printed circuit board, stand alone VFD assemblies, and configured VFD systems.

b. Factory test the complete variable frequency drive system in accordance with IEEE and NEMA standards with these Specifications. In addition, the variable frequency drive system shall be tested for efficiency as defined in this Specification.

c. Variable frequency drive system components, including power transistors and diodes, shall be 100 percent inspected and tested using the manufacturer’s standard ‘run-in’ test methods.

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d. After the specified inspections and tests have been successfully completed, the variable frequency drive system shall undergo four (4) hour operational test at 100 percent motor load without an unscheduled shutdown.

2. Certified Shop Tests and Reports

a. Submit description of proposed testing methods, procedures, and apparatus.

b. Submit notarized and certified copies of all test reports.

c. Submit factory bench-test data to indicate that the manufacturer's proposed equipment has been tested in the specified arrangement and found to achieve specified accuracy.

3. Field Tests

a. Field tests shall be performed in accordance with requirements specified in the General Conditions, Division 1, and Section 16000, Basic Electrical Requirements.

B. Authorized representatives of the Owner shall be allowed free access to the shop at all times while work is in progress for the purpose of inspection, witnessing of tests, and obtaining information on the progress of the work. The Owner shall give the Contractor 72 hours prior notice.

C. Acceptance of a shop test does not relieve Contractor from requirements to meet field installation tests under specified operating conditions, nor does the inspection relieve the Contractor of responsibilities.

D. The Contractor shall successfully complete acceptance test procedures on the assembled drive system that demonstrate compliance with the requirements of this Specification. The test plan shall be submitted for acceptance at least 30 days prior to the planned test date.

E. Drive system shall not be shipped from the manufacturing and assembly facility until the acceptance tests are completed and the acceptance tests are completed and the results approved by the test representative.

F. Tests shall be witnessed by a representative of the Engineer. Variable frequency drive manufacturer shall notify the Engineer 2 weeks in advance and shall provide testing procedures to the Engineer 4 weeks prior to actual testing. Failure of a test shall result in rejection of the equipment until performance is in compliance with these Specifications.

G. Certification on materials and records of shop tests necessary for the inspector to verify that the requirements of the Specifications are met, shall be made available to the inspector.

H. Submit signed and dated certification that all of the factory inspection and testing procedures described herein have been successfully performed by the Contractor prior to shipment.

1.03 SUBMITTALS

A. In accordance with the procedures and requirements set forth in General Conditions and Section 01300, Submittals, the Contractor shall obtain from the equipment manufacturer and submit the following:

1. Shop Drawings

2. Harmonic Study Report

3. Programming Guides/Manuals

4. Operation and Maintenance Manuals

5. Spare Parts List

6. Special Tools List

7. Shop Test Plan

8. Reports of Certified Shop and Field Tests

B. Each submittal shall be identified by the applicable specification section.

1.04 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Drawings submitted by the manufacturer shall be complete and documented to provide the Owner with operations and maintenance capabilities.

D. Shop drawings for each VFD shall include but not be limited to:

1. Layout drawings of the variable frequency drive system that include all cabinet or enclosure dimensions, access details, and weights.

2. Layout drawings of panels or enclosures showing size, arrangement, color, and nameplates. Drawings shall include the physical arrangement of door mounted devices located on the variable frequency drive enclosure. Drawings shall also include the physical arrangement of all interior components located within the variable frequency drive enclosure. The door mounted devices and interior components shall be identified or keyed to allow coordination between the layout drawings and the schematic diagrams. Sufficient detail shall be provided for locating conduit stub-ups. Conduit stub-ups shall be coordinated with the location of integral output load reactors or filters. General "catalog data sheet" layout drawings which are not specific to the systems specified herein are not acceptable.

3. Custom schematic and interconnection wiring diagrams of all electrical work, including terminal blocks and identification numbers, wire numbers and wire colors. Standard schematics and wiring diagrams that are not custom created by the manufacturer for the variable frequency drives for this project are not acceptable. These drawings shall be circuit specific for each motor-load combination (e.g. influent pumps). Indicate all devices, regardless of their physical location, on these diagrams. Specific equipment names consistent with the Drawings shall appear on each respective diagram.

4. Complete single line diagrams indicating all devices comprising the variable frequency drive system including, but not limited to, circuit breakers, motor circuit protectors, contactors, instrument transformers, meters, relays, timers, control devices, and other equipment comprising the complete system. Electrical ratings of all equipment and devices shall be clearly indicated on these single line diagrams.

5. Complete Bills of Material and catalog data sheets for all equipment and devices comprising the variable frequency drive system. A list of the product data sheets included in the submittal shall be provided. The individual product data sheets shall be tabbed for easy access/review commensurate with the product data sheet list.

6. Documented data regarding output reactors and filters, if provided.

7. A complete list of recommended spare parts, including item descriptions, recommended quantities, and unit costs. The recommended list should be based on a maintenance plan where the Owner will remove and replace failed items to the lowest replaceable module/component level.

8. A Compliance, Deviations, and Exceptions (CD&E) letter. If the shop drawings are submitted without this CD&E letter, the submittal will be rejected. The letter shall include all comments, deviations and exceptions taken to the Drawings and Specifications by the Contractor AND Equipment Manufacturer/Supplier. This letter shall include a copy of this specification section. In the left margin beside each and every paragraph/item, a letter “C”, “D”, or “E” shall be typed or written in. The letter “C” shall be for full compliance with the requirement. The letter “D” shall be for a deviation from the requirement. The letter “E” shall be for taking exception to a requirement. Any requirements with the letter “D” or “E” beside them shall be provided with a full typewritten explanation of the deviation/exception. Handwritten explanation of the deviations/exceptions is not acceptable. The CD&E letter shall also address deviations, and exceptions taken to each Drawing related to this specification section.

9. Confirmation that one (1) copy of VFD software shall be provided as specified herein.

E. The shop drawing information shall be completed and organized in such a way that the Engineer can determine if the requirements of these Specifications are being met. Copies of technical bulletins, technical data sheets from "Soft Cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items the Contractor intends to provide are to provide are acceptable and shall be submitted. All

submitted information shall be tabbed in a 3-ring binder with a Table of Contents for ease of review.

F. Prior to completion and final acceptance of the project, the Contractor shall furnish and install "as-built" wiring diagrams for each VFD and bypass starter. These final drawings shall be plastic laminated and securely placed inside each VFD and starter door and included in the O&M manuals.

G. Product Data shall include, but not be limited to:

1. Functional diagrams that identify major system functional blocks and interfaces.

2. Special requirements or restrictions of the motor-load combination that may result from operation on the variable frequency drive system.

H. Harmonic Study and Data shall include but not be limited to:

1. Report of Harmonic Study to determine the harmonic distortion present in the voltage and current waveforms on motor terminals and in the electrical distribution system(s) caused by the variable frequency drive system as specified herein.

2. Voltage and current waveforms supplied by variable frequency drive at the motor leads.

3. Necessary descriptions regarding calculation method, assumptions, values and notations, basis for input information, manufacturer's harmonic content data, and calculation results interpretation.

I. Programming Guides and Manuals shall be submitted. If the variable frequency drive systems require computer software or configuration, provide copies of all programming guides/manuals.

1.05 OPERATIONS AND MAINTENANCE MANUALS

A. The Contractor shall submit operation and maintenance manuals in accordance with the procedures and requirements set forth in the General Conditions, Section 01300, Submittals.

**B. All list of all factory and field entered parameters shall be provided at the end of the project. List shall include all modifications made during the startup period, with documentation and a description of each parameter.**

1.06 TOOLS, SUPPLIES AND SPARE PARTS

A. The VFD's and accessories shall be furnished with all special tools necessary to disassemble, service, repair, and adjust the equipment. All spare parts indicated herein shall be furnished by the Contractor to the Owner.

B. The Contractor shall furnish the following spare parts for each VFD:

1. Spare auxiliary equipment as specified in Article 2.09.

C. The spare parts shall be packed in containers suitable for long term storage, bearing labels clearly designating the contents and the pieces of equipment for which they are intended.

D. Spare parts shall be delivered at the same time as the equipment to which they pertain. The Contractor shall properly store and safeguard such spare parts until completion of the Work, at which time they shall be delivered to the Owner.

E. Spare parts lists, included with the shop drawing submittal shall indicate specific sizes, quantities, and part numbers of the items to be furnished. Terms such as "1 lot of packing material" are not acceptable.

F. Parts shall be completely identified with a numerical system to facilitate parts inventory control and stocking. Each part shall be properly identified by a separate number. Those parts which are identical for more than one size, shall have the same parts number.

1.07 SERVICES OF MANUFACTURER'S REPRESENTATIVE

A. The Contractor shall provide the services of a qualified manufacturer's technical representative who shall adequately supervise the installation and testing of all equipment furnished under this Contract and instruct the Contractor's personnel and the Owner's operating personnel in its maintenance and operation as outlined in the General Conditions, Division 1. The services of the manufacturer's representative shall be provided for a period of not less than as follows:

1. One trip of one (1) working day during installation and start-up/configuration of the equipment.

2. One trip of one (1) working day after acceptance of the equipment.

3. One trip of one (1) working day during the warranty period.

B. Any additional time required to achieve successful installation and operation shall be at the expense of the Contractor. The manufacturer's representative shall sign in and out at the office of the Resident representative on each day he is at the project.

1.08 IDENTIFICATION

A. Each VFD shall be identified by the circuit number and equipment name as indicated on the Drawings. A nameplate shall be securely affixed in a conspicuous place on each VFD. Nameplates shall be as specified in Section 16195, Electrical - Identification.

1.09 TRAINING

A. The Contractor shall provide training for Owner personnel. Training shall be conducted by the manufacturer's factory trained specialists who shall instruct Owner personnel in operation and maintenance of all equipment provided under this Section.

1.10 WARRANTY

A. Contractor shall warrant that the material and workmanship of all components and the operation of the variable frequency drive system and auxiliary equipment is in accordance with the latest design practices and meets the requirements of this Specification.

B. Warranty work shall include, but not be limited to, the following:

1. Replace components found to be faulty and make changes in equipment arrangement or adjustments necessary to meet the equipment or functional requirements or this Specification.

2. Warranty shall include system rewiring and substitution and rebuilt or additional equipment required during trial operation or subsequent operation of the unit during the period of this warranty.

3. Warranty shall be in effect for a period of 24 months following final acceptance of the system.

1.11 CONSTRUCTION SEQUENCING

A. The Contractor shall reference Section 01520, Maintenance of Utility Operations During Construction, of these Specifications.

PART 2 -- PRODUCTS

2.01 MANUFACTURERS

A. The equipment covered by this Specification is intended to be standard equipment of proven performance. Equipment shall be designed, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

B. It is the intent of these specifications that all VFD's are to be provided as part of the pump station control panel.

C. The Contractor shall obtain the VFD's from one manufacturer.

The VFD's shall be by ABB, Siemens, Square D Company, Toshiba, or Yaskawa equivalent for 6-pulse drives. The VFDs shall be provided with harmonic distortion suppression equipment and all other equipment specified herein and indicated on the Drawings for a complete and operable system.

D. Motor control circuits shall be wired in accordance with the requirements specified herein and/or indicated on the Drawings.

E. Variable frequency drive manufacturer shall be responsible for the successful application and operation of the entire drive and control system serving the motor and driven equipment. This includes the responsibility for obtaining all load, torque, speed and performance requirements from the respective sources and integrating these into a variable frequency drive system that fulfills the requirements of this Specification.

F. The Contractor and variable frequency drive system manufacturer are cautioned regarding the review and compliance with the total Contract Documents. Typical examples are circuit breakers, motor circuit protectors, magnetic starters, relays, timers, control and instrumentation products, pilot devices including pushbuttons, selector switches and pilot lights, enclosures, conduit, disconnect switches, terminal boxes, and other equipment.

2.02 PRODUCT REQUIREMENTS

A. Variable speed drives shall be adjustable frequency, adjustable voltage, pulse width modulated (PWM) design. The units shall be microprocessor controlled, fully digitally programmable, and capable of precise and repeatable speed regulation of three phase 480 volt AC NEMA Design B induction motors. Variable frequency drives for other than NEMA Design B induction motors (e.g. NEMA Design C) shall be coordinated with the requirements of that respective load.

Drive units shall perform continuous self diagnostics as well as load and drive self check on startup.

B. All drives shall have permanently mounted programming and display modules. These modules shall provide programming access to all drive parameters, display all fault codes to assist with diagnostics and provide a display of output speed in percent or load.

C. This specification describes variable speed motor control which includes the design, fabrication, testing, installation and support requirements for variable frequency drive systems for 3-phase, squirrel cage rotor, induction motors driving pumps In addition to the variable frequency drive system, provide a motor controller for bypass starting during variable frequency drive downtime, where specified herein and indicated on the Drawings.

D. Each variable frequency drive to be a complete alternating current electric drive system including hardware, software, technical data, and spare parts necessary to accomplish variable speed operation of an induction motor and load combination in accordance with the requirements as indicated on the Drawings and as described in these Specifications. Subcontractor shall refer to Section 11130 of the Specifications for a functional control description of each variable frequency drive system.

E. Variable frequency drive system manufacturer shall be responsible for the design and performance of the entire drive system and shall either manufacture all items of equipment or supply them using coordinated specifications furnished to the original equipment manufacturers to insure compatibility and performance in accordance with this Specification. Variable frequency drive manufacturer shall coordinate with suppliers of the drive motors and driven equipment.

F. Variable frequency drive system shall be suitable for operation as part of a 480 VAC, 3-phase, 60 Hertz power distribution system. The complete variable frequency drive system shall withstand the mechanical forces exerted during short circuit conditions when connected directly to a power source having available fault current of 42,000 amperes symmetrical at rated voltage.

G. The variable frequency drive system shall be suitable to operate, at times, on a limited power source engine-generator set. The system shall be provided with equipment and devices to prevent waveform distortion as specified herein.

H. Provide control and sequence logic as specified herein and indicated on the Drawings. Control and sequence logic shall be designed such that the motor-load combination can be operated in the manual mode upon control and sequence logic failure, including all necessary personnel and equipment safety interlocks.

I. Design each variable frequency drive motor drive speed control system so that through simple programming by either factory engineers or Owner's trained operating personnel, specific control and protection functions can be attained.

2.03 DESIGN REQUIREMENTS

A. Each variable frequency drive system shall meet the requirements of this Specification without derating any of the induction motor operating parameters including service factor and nameplate horsepower. The variable frequency drive system manufacturer shall specifically identify special requirements or restrictions of the motor-load combination that may result from operation on the variable frequency drive system.

B. The variable frequency drive shall consist of a 6 pulse diode semiconductor rectifier system, direct current link, and pulse width modulated inverter. The inverter shall invert the direct current voltage into an alternating current voltage at a frequency which shall be proportional to the desired speed. This alternating current voltage and frequency shall both vary simultaneously at a constant "Volts-Per-Hertz" ratio to operate the induction motor at the desired speed.

C. Variable frequency drive shall operate from fixed frequency power supply and convert this input power into variable speed induction motor shaft power as required by this Specification. Provide each variable frequency drive with an input disconnecting means as indicated on the Drawings which shall be padlockable. Provide each variable frequency drive with 5% line reactors at the input. Include the necessary drive controllers and input/output contactors to accomplish the intended control of the variable frequency drive system.

D. The drive shall operate the motor and produce full rated nameplate horsepower at the motor output shaft without exceeding motor nameplate full load current and with the motor not exceeding rated total temperature not including the additional temperature increment that constitutes the motor service factor. Motor shall retain its service factor when operated by the variable frequency drive.

E. The overall drive system efficiency shall be a minimum of 95 percent when operating the specified motor-load combination at rated voltage, frequency, and current.

This efficiency shall be calculated as follows:

$$\text{Efficiency (\%)} = \frac{\text{Power (Load)}}{\text{Power (Supply)}} \times 100$$

F. Power (Load) is the total 3-phase power delivered to the motor, measured at the output terminals of the drive system, including output filters or transformers. Power (Supply) is the total electrical power delivered to the drive system, measured at the input terminals of the

variable frequency drive including input filters, line reactors, isolation transformers, or other harmonic distortion suppression equipment. Include power input required for auxiliary equipment (e.g., controls, fans, air conditioning, pumps) for complete system operating in this Power (Supply) total.

G. Variable frequency drive shall provide smooth, stepless changes in motor speed and acceleration over the entire operating speed range from minimum to maximum speed (revolutions per minute). The variable frequency drive shall be provided with maximum and minimum frequency limits.

H. Variable frequency drive system to maintain a desired output frequency (setpoint) with a steady state accuracy of 0.5 percent of rated frequency of 60 Hertz for a 24 hour period.

I. Variable frequency drive to 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 variable frequency drive 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.

Variable frequency drive shall be furnished with programmable electronic overload and torque limits.

J. Drive system shall achieve a desired output frequency (setpoint) with a repeatability of 0.1 percent of rated frequency of 60 Hertz.

K. Drive system to be capable of operating the specified load continuously at any speed within the operating speed range of 10 percent to 100 percent of rated speed. The minimum and maximum continuous operating speeds shall each be adjustable within this speed range. The variable frequency drive shall provide for field adjustment of these setpoints.

L. Drive system controls to be microprocessor-based and have controlled linear acceleration capability to ramp up the speed, revolutions per minute, of the motor-load combination from the minimum selected operating speed to the maximum selected operating speed in a minimum of 30 seconds. Provide two (2) field-adjustable speed setpoints for the variable frequency drive to skip equipment resonant frequencies. Provide controlled linear deceleration capability. The acceleration and deceleration time limits shall be field adjustable to values up to 120 seconds.

M. Voltage or current unbalance between phases of the variable frequency drive output voltage shall not exceed 3 percent of the instantaneous values. The variable frequency drive system shall continuously monitor the output voltages and generate an alarm condition when the unbalance exceeds 3 percent. The system shall detect and generate a separate alarm for loss of any output phase voltage (single phasing). Phase unbalance shall be as defined by NEMA Standard MG-1.

N. Variable frequency drive system to operate continuously without interruption of service or damage to equipment during transient input voltage variations of plus or minus 10 percent for a duration of 15 cycles. Unacceptable voltage fluctuations on the supply bus shall cause under or overvoltage protection to trip and remove supply voltage from the drive system. Variable frequency drive output voltage regulation shall be plus or minus 2 percent.

The variable frequency drive system shall be furnished with line surge protection.

**O. The VFD shall be sized one standard size larger than the required VFD rating associated with the motor nameplate full load current (for example a 30hp motor application shall be provided with a VFD suitable for starting and operating a 40hp motor).**

P. Variable frequency drives shall be provided with output reactors where indicated on the Drawings or filters to prevent elevated voltage levels at the motor terminals. Filters or output reactors shall be provided by the VFD manufacturer if the cable length between the VFD and the motor is expected to cause elevated voltage levels at the motor terminals that exceed the ratings of the inverter duty rated motor winding insulation. VFD manufacturer shall provide output reactors or filters unless it can be proven to the Engineer in writing that the devices are unnecessary.

If the VFD manufacturer can provide documented data in Shop Drawings that shows output load reactors or filters not required to mitigate reflected wave as a concern, then output load reactors or filters will not be required. However, any related problems in the field shall be corrected at the VFD manufacturer's expense.

Q. VFD circuitry shall be designed such that the cooling fans only run when the VFD is producing and output. Designs that allow the VFD cooling fans to run continuously when the VFD is energized but not producing an output are not acceptable. The enclosure cooling fans shall stop after a suitable time delay after the VFD stops producing an output.

2.04 OPERATING CONDITIONS

A. The following operating conditions are applicable for all equipment of this Specification.

1. Humidity: 0-95 percent (ambient temperature).

2. Ambient Temperature: 0-50 degrees Celsius (ambient temperature).
0-40 degrees Celsius (enclosed).

3. Altitude: up to 3,300 feet

4. Power Supply: 480 volts, 3-phase, 60 Hertz.

5. Available Short Circuit Duty: as specified herein.

2.05 SYSTEM FEATURES AND CHARACTERISTICS

A. A Human Interface Module (HIM) shall be furnished to provide controls and indicators to accomplish operation and maintenance functions as specified herein and indicated on the Drawings. The HIM provided for the VFDs shall be the same as provided for the reduced voltage solid state starters. As a minimum, each VFD shall provide indication of the following:

1. Digital Speed Indicator: Revolutions per minute (input from tachometer).

2. Variable Frequency Drive Mode Indicator: Red; as required.

3. Bypass Mode Indicator: Red; as required.

4. Input Voltage

5. Output Voltage

6. Output Current

7. Output Frequency

8. Output Speed: 0-100%

9. Drive Ready Indicator: White

10. Run Indicator: Red.

11. Stop Indicator: Green.

12. Enclosure Overtemperature.

13. Alarm Indicator: Amber.

14. Alarm Read-out: Display.

B. Each VFD shall provide the following minimum automatic and manual control functions:

1. Hand-Off-Auto Selector Switch (as required)

2. Start and Stop Push Buttons (as required)

3. VFD-Bypass Selector Switch (as required)

4. Local-Auto Speed Control Selector Switch (as required)

5. Local Speed Increase/Decrease

6. Alarm Reset Push Button

7. 120VAC Coil Pilot Relay for Remote Run Command

8. Alarm auxiliary contacts and other devices as indicated on the Drawings and specified.

9. Provision for a run permissive from other equipment when the VFD is in “Auto”

C. Each VFD shall provide "potential-free" output contacts for the following conditions:

1. Drive running.

2. Drive in "Remote" and all trip conditions cleared.

Pilot devices shall be as specified in Section 16902, Electrical Controls and Relays.

D. Variable frequency drive system shall provide a 4-20 mADC output signal that is proportional to the drive output frequency for use as speed feedback or control and remote speed indication.

E. Variable frequency drive system shall accept a 4-20 mADC 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, revolutions per minute, equal to or less than 0.1 percent of rated speed.

F. When operating in the automatic mode, the variable frequency drive system shall shut down during a power outage. Upon restoration of normal power and after an adjustable time delay (0-2 minutes; motor has coasted to zero speed and there is no backspin), the variable frequency drive system shall automatically restart and then ramp up to speed as required by the control system. The process operator shall not be required to reset the system manually after a shutdown caused by a power outage.

G. Variable frequency drive shall be furnished with a multiple attempt restart feature.

H. Furnish a door mounted device or function for those variable frequency drives where an additional speed reference signal (e.g., from a remote potentiometer, an analog output from a setpoint (PID) controller, an analog output from the plant control system, or similar analog signal) is to be supplied to the variable frequency drive in addition to the door mounted manual speed control.

I. Provide a circuit breaker with shunt trip coil and current-limiting fuses (if required) for each variable frequency drive. Provide each variable frequency drive with its respective drive controller for each motor.

J. Include in each variable frequency drive system an automatic trip feature which will remove the drive output from the motor and allow it to decelerate safely. This automatic system shall trip and indicate the fault only upon the following conditions:

1. Output voltage unbalance (trip threshold field set).

2. Open phase.

3. Motor overload.

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

5. Loss of input power to the variable frequency drive or unacceptable voltage variation.

6. High variable frequency drive equipment temperature.

7. Variable frequency drive system failure as determined by the manufacturer.

8. Component failure.

9. Overcurrent.

10. Undercurrent.

K. Provide each variable frequency drive system 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 drive controller as standard, this feature shall be capable of being disabled.

L. Variable frequency drive design shall include on-line diagnostics, with an automatic self-check feature that will detect a variable frequency drive failure which in turn affects motor operation and generates an alarm contact output rated for 125 VDC suitable for interfacing with the control system.

1. Diagnostics shall operate a visual alarm indicator that is visible on the variable frequency drive equipment cabinets without opening the cabinet doors.

2. Diagnostics shall provide an easily readable output that will isolate a failure.

3. Provide an easily accessible fault buffer (up to 16 faults in FIFO status). These faults shall be capable of being monitored and extracted by a PLC over the network. The VFD manufacturer shall provide one (1) copy of the software to extract any fault buffer information.

4. Provide a normally open dry contact for each alarm function to enable remote indication.

2.06 ENCLOSURES

A. VFD to be provided as part of the Pump Station Control Panel enclosure.

2.07 HARMONIC DISTORTION SUPPRESSION

A. A comprehensive pre-equipment-selection harmonic study shall be prepared by the VFD manufacturer. The results of this pre-equipment selection study shall be submitted to the Engineer as part of the submittals specified herein. Should this study indicate the need for tuned filters, line reactors, isolation transformers, or other harmonic distortion suppression equipment, these devices shall be supplied and installed at no additional cost to the Owner. Indicate the location of the harmonic suppression equipment in the submittal data. Location is subject to acceptance by the Engineer.

B. The harmonic distortion values at the point of common coupling (PCC) indicated on the Drawings resulting from operation of all or any variable frequency drive-driven motor-load combinations operating at full load shall be as defined in IEEE Standard 519.

1. Maximum allowable total harmonic voltage distortion (THD): 5 percent of the fundamental.

2. Maximum allowable individual frequency harmonic voltage distortion: within the limits of IEEE standard 519.

3. Maximum allowable total demand distortion (TDD): within the limits of IEEE Standard 519-1992, Table 10.3.

4. Maximum allowable individual frequency harmonic demand distortion: within the limits of IEEE Standard 519-1992, Table 10.3.

5. The harmonic distortion levels shall be specific to the "Point of Common Coupling" (PCC) as defined in IEEE Standard 519 and indicated on the Drawings.

C. System single line diagrams are provided to the VFD manufacturer for the purpose of providing this study. The VFD manufacturer shall obtain from others information that may be necessary to perform this study. Input data and other pertinent information used in harmonic study shall be coordinated by the Contractor with the following:

1. Input data/information/results of the short circuit fault analysis specified herein.

2. Electrical system configuration and electrical equipment shop drawing submittal data including, but not being limited to new non-linear loads, new linear loads, and new capacitors.

D. Preparation of this pre-equipment selection study does not relieve the requirement for the VFD manufacturer to perform and submit the results of a second, final comprehensive study after equipment installation.

E. In addition, the Contractor shall field measure actual harmonic distortion and verify with tests performed by an independent authority acceptable to the Owner after satisfactory full-load operation.

F. As part of the specified harmonic studies and other work for this project, the Contractor shall identify and correct resonance conditions in the electrical distribution system at no additional cost to the Owner. Shop drawings, data, location of the respective equipment and its connection to the electrical distribution system shall be acceptable to the Engineer.

G. Reference Section 16000, Basic Electrical Requirements for information gained from the electric utility company during the design period which could be used for the purpose of the harmonic study. Inclusion of this information, however, does not relieve the Contractor nor his suppliers of the responsibility of obtaining all the necessary information required to perform the harmonic study.

2.08 MISCELLANEOUS

A. Encapsulate critical components in ceramic or metal.

B. Auxiliaries, including fans, that are required for rated load operation at maximum ambient temperature, shall be 100 percent redundant. A new and unused spare replacement fan(s) or air conditioning unit(s), shipped in original carton, may be acceptable.

C. Circuit boards and electrical components shall meet the corrosion protection requirements specified in these Specifications. Varnished or epoxy encapsulated circuit boards and tropicalized contactors suitable for corrosive environments shall be furnished where the VFDs are not located in climate controlled areas.

## PART 3 -- EXECUTION

### 3.01 INSTALLATION

A. The VFD's shall be installed as shown on the Drawings and in accordance with the manufacturer's installation instructions.

B. Install VFD's to allow complete door swing required for component removal.

C. Include in the bid an allowance for factory-trained service personnel, other than sales representatives, to supervise field installation, inspect, make final adjustments and operational checks, make functional checks of spare parts, and prepare a final report for record purposes. Adjust control and instrument equipment until this equipment has been field tested by the Contractor and the results of these tests have been accepted by the Engineer.

- END OF SECTION -

SECTION 16496

AUTOMATIC TRANSFER SWITCH

## PART 1 -- GENERAL

### 1.01 THE REQUIREMENT

A. The Contractor shall furnish, install, connect, test and place in satisfactory operation automatic transfer switches with surge protection device as specified herein and indicated in Drawings.

B. All devices and components of the automatic transfer switch shall be NEMA rated. IEC rated devices are unacceptable and shall be cause for rejection of the submittals/equipment.

C. Section includes automatic transfer switches in individual enclosures with surge protection devices. Switches herein are intended for use with Packaged Engine Generators, and shall be separately mounted on an electrical rack according to the design drawings. Locations is outdoors, exposed to weather and the enclosure of the transfer switch shall be rated NEMA 4X, in a 304 SST enclosure.

D. Transfer switch functions to monitor normal utility line voltage, and upon loss or failure of normal utility voltage, automatically start the engine generator set and transfer load circuits to the stand-by generator. Automatic transfer switch must automatically re-transfer load circuits back to the normal utility source when acceptable utility power supply conditions are restored, and subsequently direct the generator to cool-down and then shut down actions.

E. All switching actions are “open-transition”.

### 1.02 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the Contractor shall obtain from the equipment manufacturer and submit the following:

1. Shop Drawings

2. Operation and Maintenance Manuals

3. Special Tools List

4. Reports of certified shop tests

5. Guarantee/Warranty Program

B. Each submittal shall be identified by the applicable specification section.

### 1.03 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete or illegible submittals will be returned to the Contractor for resubmittal without review.

C. Shop drawings for each automatic transfer switch shall include but not be limited to:

1. Product data sheets.

2. Complete assembly, layout, and installation drawings with clearly marked dimensions and conduit entrance locations.

3. Example equipment nameplate data sheet.

4. Complete internal schematic and interconnecting wiring diagrams. Standard wiring diagrams that are not custom created by the manufacturer for the automatic transfer switch for this project are not acceptable.

5. Nameplate schedule.

6. Manufacturer's standard installation instructions.

7. Manufacturer's standard warranty.

D. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items the Contractor intends to provide are acceptable and shall be submitted.

E. Prior to completion and final acceptance of the project, the Contractor shall furnish and install "as-built" wiring diagrams for each automatic transfer switch. These final drawings shall be plastic laminated and securely placed inside each transfer switch and included in the O&M manuals.

1.04 OPERATION AND MAINTENANCE MANUALS

A. The Contractor shall submit operation and maintenance manuals in accordance with the procedures and requirements set forth in the General Conditions and Division 1.

1.05 TOOLS AND SUPPLIES

A. The automatic transfer switches shall be furnished with all special tools necessary to disassemble, service, repair and adjust the equipment. All spare parts as recommended by the equipment manufacturer shall be furnished to the Owner by the Contractor.

1.06 IDENTIFICATION

A. Each automatic transfer switch shall be identified with the identification number indicated on the Drawings (e.g. ATS-PS, etc.). A nameplate shall be securely affixed in a conspicuous place on each switch. Nameplates shall be as specified in Section 16195, Electrical - Identification.

1.07 WARRANTY

A. The manufacturer shall warrant each automatic transfer switch for a minimum of five (5) years from date of shipment. In addition, the manufacturer shall repair or replace equipment found faulty under the terms of the warranty. The manufacturer shall submit data outlining the guarantee/warranty program.

1.08 CONSTRUCTION SEQUENCING

A. The Contractor shall reference Section 01520, Maintenance of Utility Operations During Construction, of these Specifications.

PART 2 -- PRODUCTS

2.01 MANUFACTURERS

A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

B. The equipment described herein, as a minimum, shall meet all of the requirements specified in this Section and shall be a product of a manufacturer who has produced automatic transfer switches for a period of at least five (5) years. The equipment shall be compatible with the loads to be served. Assembly of the switches by a fabricator is not acceptable.

C. The manufacturer of the automatic transfer switch shall verify that the switches are listed by Underwriters Laboratories, Inc., standard UL-1008, with 3-cycle withstand and close-in values as indicated on the Drawings or specified herein. Switch shall be NEMA ICS 10.

D. The automatic transfer switches shall be as manufactured by engine-generator supplier. Transfer switch to be the standard provided by the Engine-Generator Supplier.

2.02 AUTOMATIC TRANSFER SWITCH

A. General

1. Transfer Switches shall have be 3-phase, 4-pole, 4-wire, with a switched neutral as indicated on the Drawings and shall be suitable for 480 VAC, three-phase, 60 Hertz operation.

2. For three phase, four-wire systems, a true four-pole switch shall be supplied with all four electrically and mechanically identical poles mounted on a common shaft. The continuous current rating and the closing and withstand rating of the fourth pole shall be identical to the rating of the main poles.

3. Configuration: Electrically operated, mechanically held transfer switch; interlocked to prevent closing on two sources simultaneously.

4. Ratings: As identified on the project design drawings.

5. Interrupting Capacity: Minimum of 100 percent of continuous rating.

6. The transfer switch shall have both top and bottom mounted cable access.

7. The switch shall be capable of switching all classes of load and rated for continuous duty when installed in a non-ventilated enclosure.

8. The three-cycle closing and withstand current rating of the switch shall be 42,000 amperes RMS (minimum). This rating shall not be restricted by the use of a specific manufacturer's circuit breaker.

9. This switch shall be complete with all accessories and listed by UL under Standard UL-1008 for use on emergency systems.

10. All bolted bus connections shall have Belleville compression type washers. Switches for four-wire systems shall be furnished with a fully rated solid neutral bus.

11. The switch shall be equipped with 90°C rated copper/aluminum solderless mechanical type lugs of the proper quantity and size to accommodate the termination of field wiring.

12. Switches shall be capable of normal operation during and after seismic loading. Seismic loading shall not cause false operation.

13. Service conditions:

    a. Temperature: 104 degrees F.
    b. Altitude: 500 feet above sea level, for design purposes.

B. Product Features:

1. Indicating Lights: (in accordance with paragraph I below)

    a. Normal Available – Normal supply is available and is within voltage/frequency sensor tolerances.

    b. Stand-by Available – Stand-by supply is available and is within voltage/frequency sensor tolerances.

    c. Timing for Transfer – Control is timing out to transfer from normal to standby supply.

    d. Timing for Re-transfer – Control is timing out to re-transfer from stand-by to normal supply.

    e. Remote run – Control is signaling for the stand-by supply to start / run.

f. Transfer – Control is signaling for transfer to the stand-by supply.

g. Re-transfer – Control is signaling for re-transfer back to normal supply.

h. Timing for Stop – Control is timing out for the stand-by supply to stop.

2. Starting Contacts: provide pilot contacts as required to operate generator in all modes.

3. Test Switch: Mount in cover of enclosure to simulate failure of normal source.

4. Manual Operation Selection: Designed and tested for safe transfer and retransfer of the load, while loaded, with either or both the normal and alternate power source terminals energized. Manual operation is “programmed transition”.

5. Transfer Switch Auxiliary Contacts: 1 normally open; 1 normally closed.

6. Normal Source Control Settings: Monitor each line of normal source voltage and frequency. Under-voltage: dropout range 75-98 percent factory set for 80 percent; pickup range 85-100 percent factory set for 90 percent. Under-frequency: dropout range is 2 Hz below factory set frequency; pickup range 90-100 percent factory set for 90 percent.

7. Alternate (Stand-by) Source Control Settings: Monitor each line of alternate source voltage and frequency. Under-voltage: dropout range 75-98 percent factory set for 80 percent; pickup range 85-100 percent factory set for 90 percent. Under-frequency: dropout range is 2 Hz below factory set frequency; pickup range 90-100 percent factory set for 95 percent.

8. In-Phase Monitor: Self adjusting or inhibit transfer until source and load are within two electrical degrees.

9. Switched Neutral: Non-Overlapping contacts.

10. Contacts: Each pole shall be of high-pressure contact design, with a bi-directional linear actuator operator that shall operate in either direction in 6 seconds or less. Contacts shall be solid silver cadmium oxide (stationary) and silver tungsten (movable), capable of switching both inductive and resistive loads. Thermal capacity of each contact shall allow for inrush currents at least 20 times the continuous rating. Contact pressure chambers must have arc chutes to provide are quenching and to prevent cross arcing between poles.

C. Automatic Sequence of Operation:

1. Initiate Time Delay to Start Alternate Source Engine Generator: Upon initiation by normal source monitor.

2. Time Delay To Start Alternate Source Engine Generator: 0 to 10 seconds, adjustable.

3. Initiate Transfer Load to Alternate Source: Upon initiation by normal source monitor and permission by alternate source monitor.

4. Time Delay before Transfer to Alternate Power Source: 0 to 120 seconds, adjustable.

5. Initiate Retransfer Load to Normal Source: Upon permission by normal source monitor.

6. Time Delay before Transfer to Normal Power: 0 to 30 minutes, adjustable; bypass time delay in event of alternate source failure.

7. Time Delay Before Engine Shut Down: 0 to 5 minutes, adjustable, of unloaded operation.

8. Engine Exerciser: Start engine every 7 days; run for 30 minutes before shutting down. Bypass exerciser control when normal source fails during exercising period.

9. Alternate System Exerciser: Transfer load to alternate source during engine exercising period.

D. Enclosure: Gen-Set unit mounted by factory.

1. Enclosure: ICS 10, Type 4, weather-proof, with quarter-turn, 3-point lockable latch.

2. Finish: Manufacturer's standard.

E. Surge Protective Device (SPD): The ATS shall be equipped with an internal, factory installed surge protective device. The UL 1449, 3nd Ed., Type 4 surge protective device (SPD) shall provide line-voltage surge protection for the control panel power bus and starters. The SPD shall have a minimum surge rating of 250kA/phase, with each phase having its own status indicator light. Surge current modes are Line to Neutral, Line to Ground, Neutral to Ground, and Line to Line. The SPD shall be provided with a line-side, manual disconnecting circuit breaker to simultaneously disconnect all ungrounded conductors for maintenance.

F. All control wiring shall be 18 gauge (minimum), 600 VAC, SIS switchboard type. All control wiring shall be identified at each termination (both ends) using tubular, sleeve-type wire markers.

G. The automatic transfer switch controller shall be manufactured by the transfer switch manufacturer. The controller shall be programmed by the manufacturer at the factory.

2.03 ENCLOSURES

A. The transfer switches shown to be installed outdoors shall be housed in a NEMA 4X, 304 stainless steel enclosure. Enclosure shall be in a free-standing enclosure, or rack mounted, as recommended by the manufacturer based on the size of the equipment. The enclosure shall exceed the UL-1008 minimum wire bending space requirements. The enclosure shall be equipped with an internal, welded steel, door-mounted print pocket.

PART 3 -- EXECUTION

3.01 INSTALLATION

A. Each automatic transfer switch shall be installed as shown on the Drawings and in accordance with the manufacturer's installation instructions.

3.02 TESTING

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

1. Witnessed Shop Tests

a. Not required.

2. Certified Shop Tests and Reports

a. Automatic transfer switches shall be given routine factory tests. The factory tests shall demonstrate that the completed switches function correctly and that the required timing has been set. Certification of these settings shall be submitted to the Engineer upon request.

b. Test procedures shall be in accordance with UL-1008. During the 3-cycle withstand tests, there shall be no contact welding or damage.

c. The three cycle tests shall be performed without the use of current limiting fuses.

d. Oscillograph traces across the main contacts shall verify that contact separation has not occurred and there is contact continuity across all phases after completion of the test.

e. When conducting temperature rise tests in accordance with UL-1008, include post-endurance temperature rise tests to verify the ability of the transfer switch to carry full rated current after completing the overload and endurance tests.

f. Manufacturer shall submit test reports upon request.

3. Field Tests

a. Field testing shall be done in accordance with the requirements specified in the General Conditions, Division 1, and Section 16000, Basic Electrical Requirements.

b. Prior to acceptance of the installation, load test the equipment with all available motor load, but do not exceed the generator's or automatic transfer switch's nameplate rating. Correct defects which become evident during this test.

c. Inspect and test in accordance with NETA ATS, except Section 4.

d. Perform inspections and tests listed in NETA ATS, Section 7.22.3.

3.03 SERVICES OF MANUFACTURER'S REPRESENTATIVE

A. The Contractor shall provide the services of a qualified, factory-trained manufacturer's technical representative who shall adequately supervise the installation and testing of all equipment furnished under this Contract. The manufacturer's representative shall certify in writing that the equipment has been installed in accordance with the manufacturer's recommendations. No further testing or equipment startup may take place until this certification is accepted by the Owner.

B. The manufacturer's technical representative shall perform startup and functional testing of the transfer switch as specified herein.

C. The Contractor shall provide training for Owner personnel. Training shall be conducted by the manufacturer's factory-trained representative who shall instruct Owner personnel in operation and maintenance of all equipment provided under this Section. Training shall be provided for two (2) sessions of two (2) hours each. Training shall be at times coordinated with the Owner, and shall occur during the same day as the training specified in Section 16620 – Packaged Engine Generator Systems.

D. The services of the manufacturer's representative shall be provided for a period of not less than as follows:

1. One (1) trip of one (1) working day during the installation and startup of each transfer switch.

2. One (1) trip of one (1) working day after Owner acceptance of the equipment assembly (if required).

E. Any additional time required to achieve successful installation and operation shall be at the expense of the Contractor.

- END OF SECTION –

SECTION 16620

PACKAGED ENGINE GENERATOR SYSTEMS

## PART 1 -- GENERAL

### 1.01 THE REQUIREMENT

A. The Contractor shall furnish and install a standby power engine generator set complete with base-mounted fuel storage tank, leak detection systems, piping, exhaust silencer, batteries, charger, enclosure, and devices for automatic and manual control.

B. It is the intent under this Contract to require an installation complete in every detail whether or not indicated on the Drawings or specified. Consequently, the Contractor is responsible for all details, devices, accessories and special construction necessary to properly install, adjust, test, and place in successful and continuous operation the engine-generator set.

C. Use materials which are new, unused, and as specified, or, if not specifically indicated, the best and most suitable of their kinds for the purpose intended, and for the design and expected conditions of service, subject to the approval of the Engineer.

D. Provide workmanship that is first class in every respect. Employ workers thoroughly experienced in such work. A neat and workmanlike appearance in the finished work shall be required.

E. All materials used must bear the inspection labels of the Underwriter's Laboratories, if the material is of a class inspected by the Laboratory.

F. Unless otherwise indicated, the materials to be provided under this Specification shall be the products of manufacturers regularly engaged in the production of all such items and shall be the manufacturer's latest design. The products shall conform to the applicable standards of UL and NEMA, unless specified otherwise. International Electrotechnical Commission (IEC) standards are not recognized. Equipment designed, manufactured, and labeled in compliance with IEC standards is not acceptable.

G. The engine generator sets shall fully comply with all current Environmental Protection Agency (EPA) emission regulations including, but not limited to, the New Source Performance Standards (NSPS) for stationary and non-road generator sets. The engine generator set(s) must meet the EPA new source performance requirements required at the time the engine generator set(s) submittal is approved by the Engineer. Engines manufactured previous to the submittal approval date that do not meet the current regulated emissions levels are not acceptable.

H. The Engine-Generator System Supplier shall furnish the packaged engine-generator system with an automatic transfer switch. **Breaking out this automatic transfer switch from the Engine-Generator System Supplier’s scope of supply is NOT ACCEPTABLE.** Reference Section 16496, Automatic Transfer Switch.

I. Then Engine-Generator shall conform to the requirements of NFPA 110.

1.02 CODES AND STANDARDS

A. The packaged engine-generator system shall comply with the following Codes and Standards as a minimum:

1. NEMA MG1, Motors and Generators.

2. NEMA MG2, Safety Standard for Construction and Guide for Selection, Installation and Use of Motors and Generators.

3. ISO STD 8528, Reciprocating Internal Combustion Engines.

4. ISO STD 3046, Performance Standard for Reciprocating Internal Combustion Engines.

5. NFPA 30, Flammable and Combustible Liquids Code.

6. NFPA 37, Standard for Installation and use of Stationary Combustible Engine and Gas Turbines.

7. NFPA 70, National Electrical Code

8. NFPA 70E, Standard for Electrical Safety in the Workplace

9. NFPA 110, Standard for Emergency and Standby Power Systems.

10. UL 508, Industrial Control Equipment.

11. EGSA, Electrical Generating Systems Association.

12. UL 2200 – Stationary Engine Generator Assemblies

13. ANSI C57, Dry-Type Transformers.

14. UL 142, Steel Aboveground Tanks for Flammable and Combustible Liquids.

1.03 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the Contractor shall obtain from the equipment manufacturer and submit the following:

1. Shop Drawings

2. Spare Parts List

3. Special Tools List

4. Reports of Certified Shop and Field Tests

5. Operation and Maintenance Manuals
6. Manufacturer's Field Start-up Report

7. Manufacturer's Representative's Installation Certification

B. Each submittal shall be identified by the applicable specification section.

1.04 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings for engine-generator set shall include but not be limited to:

1. A Compliance, Deviations, and Exceptions (CD&E) letter. If the shop drawings are submitted without this CD&E letter, the submittal will be rejected. The letter shall include all comments, deviations and exceptions taken to the Drawings and Specifications by the Contractor AND Equipment Manufacturer/Supplier. This letter shall include a copy of this specification section. In the left margin beside each and every paragraph/item, a letter “C”, “D”, or “E” shall be typed or written in. The letter “C” shall be for full compliance with the requirement. The letter “D” shall be for a deviation from the requirement. The letter “E” shall be for taking exception to a requirement. Any requirements with the letter “D” or “E” beside them shall be provided with a full typewritten explanation of the deviation/exception. Handwritten explanation of the deviations/exceptions is not acceptable. The CD&E letter shall also address deviations, and exceptions taken to each Drawing related to this specification section.

2. Standard manufacturers printed specification sheet showing critical engine and generator set specifications including the following:

- Dimensions, and weights
- Guaranteed fuel consumption at 25%, 50%, 75% and 100% of full rated load
- Engine bhp available
- Engine jacket water heat rejection
- Exhaust flow rate and temperature at 100% of rated load
- Ventilation and combustion air requirements
- Exhaust backpressure limitation
- Liquid refill capacities
- Generator efficiency at 50%, 75%, and 100% load
- Telephone Interference Factor (TIF)

- Guaranteed noise levels
- Brake Mean Effective Pressure (BMEP)

3. Alternator technical electrical data including, but not limited to:

   - Per unit subtransient impedance X'' and X/R ratios for positive, negative, and zero sequences
   - Transient reactance (Xd')
   - Synchronous reactance (Xd)
   - Sub transient time constant (Td'')
   - Transient time constant (Td)
   - DC time constant (Tdc)
   - Decrement curve
   - Harmonic waveform distortion
   - Type of winding insulation and alternator temperature rise
   - Voltage regulation characteristics

4. The engine-generator set manufacturer's printed standard warranty statement of the engine and generator set showing single source responsibility by the engine manufacturer.

5. Generator control panel equipment and features. Include a written explanation of the auto start/stop logic and operation.

6. Engine-generator set and accessory product data sheets including, but not limited to, the following:

   - Alternator strip heater
   - Radiator
   - Seismically rated vibration isolators
   - Flexible exhaust coupling
   - Exhaust silencer
   - Batteries
   - Battery charger
   - Engine manufacturers shutdown contactors
   - Fuel lines
   - Jacket coolant heater
   - Fuel cooler
   - Fuel tank(s) and pump(s)
   - Fuel level devices
   - Conduit
   - Wire and Cable

- Wiring Devices
- Lighting
- Panelboards

7. Detailed statement concerning non-engine-generator set manufacturer's warranty policies, the packaged engine-generator set dealer's responsibility, and duration of policy.

8. Normal operating ranges for systems temperature, pressure and speed.

9. Manufacturer's part number for the engine and generator operation guide, parts book, service manual, warranty policy, and installation guide.

10. Phone numbers of twenty-four (24) hour products support contacts and locations.

11. Drawing showing right hand, left hand, and top views of proposed assembly; battery rack, isolators, exhaust silencer, conduit stub up locations, and flexible fittings; wiring schematics, interconnection diagrams (point to point), and written description of engine generator controls and alarm circuits.

12. Local engine-generator set monitoring and control panel layout drawings and wiring diagrams.

13. Drawings and specifications for base-mounted fuel storage tank with accessories and leak detection system.

14. Detailed drawings showing plan, front, and side views as well as appropriate section views of the weatherproof, engine-generator enclosure. Include product data sheets for all appurtenances (e.g. lighting, switches, receptacles, etc.) to be furnished and installed in the enclosure. Drawings shall be of sufficient detail to assure proper installation by the Contractor.

15. Certification confirming proof of compliance with all requirements with respect to noise attenuation and exhaust emissions.

D. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these Specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items the Contractor intends to provide are acceptable and shall be submitted.

1.05 REPORTS OF CERTIFIED SHOP AND FIELD TESTS

A. Submit two (2) certified copies of all test reports. This includes all shop tests and field tests. Certified shop test reports for prototype engine-generator sets are unacceptable. The manufacturer’s serial number for the actual engine-generator set furnished for this project shall appear on all test reports.

1.06 OPERATION AND MAINTENANCE MANUALS

A. The Contractor shall submit operation and maintenance manuals in accordance with the procedures and requirements set forth in the General Conditions and Division 1.

B. Furnish identical bound instruction manuals (quantities as defined in Division 1) covering operating procedures, lubrication, and maintenance requirements of all equipment furnished under this Item. Include wiring and piping diagrams, drawings, product data sheets, parts lists, and other necessary data. Number or otherwise clearly identify all parts to facilitate ordering of replacements. Exclude data not pertinent to this installation.

C. Include instructions for normal operation, instructions for routine maintenance requirements, service manuals for engine, alternator, fuel system components, fuel tank, and electrical components. Include oil sampling and analysis for engine wear, and emergency maintenance procedures.

D. Manufacturer's Warranty or Certificate: Certify that Products meet or exceed specified requirements, and provide a 5-year warranty against defects in material and factory workmanship with a 2-year service contract. The warranty period will begin on the date of the issuance of Permit to Operate. If the Permit to Operate for the system is not issued within twelve (12) months of the startup inspection, another startup inspection must be conducted and be found satisfactory for BCWS to accept and assume O&M responsibilities.

E. Manufacturer's Field Reports and System Calculation: Indicate procedures and findings. Calculation shall be issued by manufacturer to demonstrate that this unit will suitably drive the connected loads, as specified on project design drawings.

F. Contractor’s Field Reports: Provide reports showing that all manufacturer recommended maintenance has been performed on the generator since delivery was taken, and provide documentation showing that the fuel in the generator has been replaced or cleaned within 30 days of the issuance of Permit to Operate.

1.07 TOOLS AND SUPPLIES

A. The engine-generator systems shall be furnished with all special tools necessary to disassemble, service, repair and adjust the equipment as part of a regular maintenance program. All spare parts as recommended by the equipment manufacturer shall be furnished to the Owner by the Contractor.

B. The dealer shall have sufficient parts inventory to maintain over-the-counter availability of at least 90% of any required part and 100% availability within 48 hours.

1.08 IDENTIFICATION

A. Each engine-generator set shall be identified with the identification number indicated on the Drawings (e.g., Generator No.1). A nameplate shall be securely affixed in a conspicuous place on the generator main circuit breaker enclosure. Nameplates shall be as specified in Section 16195, Electrical - Identification.

1.09 WARRANTY TERMS

A. The engine-generator set manufacturer's standard warranty shall in no event be for a period of less than five (5) years from date of issuance of Permit to Operate, and shall include travel time, repair labor, travel expense necessary for repairs at the jobsite, and expendables (lubricating oil, filters, coolant, and other service items made unusable by the defect) used during the course of repair. Running hours shall not be the limiting factor for the system warranty by either the manufacturer or servicing packaged engine-generator set dealer. Submittals received without written warranties as specified shall be rejected in their entirety. If the Permit to Operate for the system is not issued within twelve (12) months of the startup inspection, another startup inspection must be conducted and be found satisfactory for BCWS to accept and assume O&M responsibilities.

B. The packaged engine-generator system dealer shall provide a complete five (5) year warranty covering all equipment included in the scope of supply. This warranty shall include, but is not limited to, the following:

- New engine-generator set and respective auxiliary equipment
- All controls for the engine-generator sets and the automatic transfer switch
- Complete diesel fuel system

C. Batteries shall be provided with five (5) year full replacement guarantee, and a pro-rated replacement schedule thereafter.

1.10 OIL SAMPLING KIT

A. The generator set supplier shall provide an oil sampling analysis kit which operating personnel shall utilize for scheduled oil sampling. All equipment needed to take oil samples shall be provided in a kit and shall include the following:

| | |
|---|---|
| 1 | Sample extraction gun |
| 10 | Bottles |
| 10 | Postage-paid mailers |
| 1 | Written instructions |

An additional oil sampling kit shall be made available to the Owner to continue the sampling when the above specified kit has been depleted. All kits in addition to that specified above shall be at an additional cost to the Owner, if the Owner desires to continue the sampling service.

1.11 CONSTRUCTION SEQUENCING

A. The Contractor shall reference Section 01520, Maintenance of Utility Operations During Construction, of these Specifications.

PART 2 -- PRODUCTS

2.01 MANUFACTURERS

A. The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

B. The engine-generator set manufacturers shall be Cummins, Caterpillar, or Kohler. **No substitutions shall be permitted.** The engine-generator set manufacturer shall be responsible for the entire engine-generator package including the engine-generator set with enclosure, fuel system, piping, automatic transfer switch, accessories, electrical equipment, and other devices for a complete and operable system.

2.02 GENERAL DESCRIPTION

A. The engine-generator set shall be rated as specified herein and as indicated on the Drawings. It shall have the capability to operate at its standby rating for the duration of any power outage with all accessories including engine running devices, silencer, radiator, cooling fans, fuel system, and all appurtenances complete as it would be installed in the field. The engine-generator set shall also have the capability to operate at is prime rating. The Contractor shall note and take appropriate action regarding the intended operation of the engine-generator sets while connected to motor driven loads controlled by variable frequency drives (VFDs).

B. The engine-generator set shall meet current EPA and South Carolina Environmental Protection Agency air quality and emission requirements and standards.

2.03 ENGINE

A. The engine shall be diesel, 6 cylinder (minimum), 4 cycle, radiator cooled via an engine shaft driven fan, and shall be turbocharged having an operating speed of 1800 RPM. The engine shall operate on ultra-low sulphur diesel fuel. Engines requiring premium fuels are not acceptable.

B. The engine will not be acceptable if the design is a conversion of a naturally aspirated engine to which a turbo-blower has been attached, unless the engine is certified by the manufacturer as having been analyzed and redesigned with ample provisions for increased stresses and bearing or heat loads due to increased pressures and rate of heat liberation.

C. Brake Mean Effective Pressure (BMEP) shall not exceed 375 psi at rated load. Brake Horsepower (BHP), and Engine-Generator efficiency shall conform to ASME, IEEE and NEMA standards that electrical energy delivered by the machine is within the minimum certified guaranteed fuel oil consumption rate and evidence that these parameters have been met shall be furnished.

D. Routine maintenance and adjustments shall be performed without the use of special tools or instruments. Only engine manufacturers' standard ratings shall be acceptable. No dealer special ratings will be acceptable.

E. The specified standby kW rating shall be for continuous electrical service during interruption of the normal utility source, per NEMA standards. If available, the prime rating shall also be indicated on the equipment nameplate and included in the submittal.

F. Engine speeds shall be governed by a digital (only) loading sharing governor that will sense generator speed and provide accurate load transient correction capability at less than 0.5 percent regulation, from no load to full load generator output. Steady state frequency regulation shall be ±0.25%, minimum.

2.04 ALTERNATOR

A. The alternator shall be manufactured by Caterpillar (SR5), Marathon, or equal and shall conform with NEMA and IEEE standards rated as indicated on the Drawings. The alternator shall have a UL2200 listing. The alternator shall be brushless, salient pole, 2/3 pole pitch and synchronous for operation at 480VAC, wye connected, as indicated on the Drawings. The alternator shall be capable of delivering 2000 SkVA (minimum) at no more than a 20% voltage drop.

B. Laminations and windings shall be designed for minimum reactance, low voltage waveform distortion and maximum efficiency.

C. The main stator coils shall be random wound with a VPI insulation system. Insulation shall be Class H, 125 degrees C rise according to NEMA Standards. The Class H insulation system shall be made of epoxies and polyesters which are inorganic compounds and shall prevent fungus growth.

D. Radio interference suppression (both directions) shall be provided in accordance with NEMA and IEEE Standards.

E. The alternator shall have a brushless, permanent magnet exciter. The exciter shall supply field excitation to maintain output with the alternator loaded to 300% of continuous rating for 10 seconds at rated power factor.

F. Waveform deviation shall not exceed 5% from true sine wave. The transient response from no load to full load in one step of the engine-generator set shall not exceed a voltage dip of 35%, a frequency dip of 20%, and shall recover to complete steady state performance within 12 seconds for both voltage and frequency. The transient response from full load to no load in one step shall not exceed a voltage overshoot of 23%, a frequency overshoot of 10% and shall recover to steady state performance within 5 seconds for both voltage and frequency. These measurements shall be made by a light beam oscillograph recorder and shall be a result of testing the engine-generator set combination. Data on generator transient response measured on an electric motor driven generator will not be acceptable in the submittal information.

G. The Telephone Influence Factor (TIF) shall be less than 50.

H. Alternator outputs shall be certified by an independent testing laboratory. Certified test reports by the alternator manufacturer shall be submitted for approval showing compliance with the requirements of the Specifications.

I. The voltage regulator shall be an adjustable, solid state, digital, three-phase RMS sensing, volts/hertz type. The voltage regulator shall be provided with solid state trip circuit breaker to protect the exciters from time overcurrent. The voltage regulator shall be located within the engine control panel.

J. An alternator mounted strip heater shall be furnished and installed as part of the system. The strip heater shall be "ON" to prevent condensation when the engine generator set is not running.

2.05 CONTROLS

A. Engine-generator monitoring and controls shall be mounted in a single NEMA 1 dust-tight enclosure. A suitable accessible terminal strip having all wires properly identified shall be furnished for connection of field wiring. The panel shall be mounted 4'-8" measured from the center of the panel to the enclosure floor. The control panel shall accept a dry contact input for engine starting from remote locations.

B. The starting and stopping of the engine-generator set shall be initiated through the control panel only. When the engine starts, starting control shall automatically disconnect cranking controls. Four (4) cranking cycles of 10 seconds "ON", 10 seconds "OFF" shall be provided. The starting controls shall prevent re-cranking for a definite time after source voltage has been reduced to a low value, or the four (4) cranking cycles have been reached without a successful start. The automatic engine starting controls shall use industrial rated control type elements throughout, and controls shall have the capability to operate at 50% battery voltage.

C. Speed sensing shall be provided to protect against accidental starter engagement with a moving flywheel. Battery charging alternation output voltage is not acceptable for this purpose.

D. A molded case generator/exciter field circuit breaker with shunt trip device shall be furnished and installed as part of the engine generator set. Shunt trip shall be activated upon engine-generator fault conditions.

E. Engine-generator monitoring and control shall be provided using a microprocessor based control panel complete with an LCD display. The devices necessary for automatic starting shall be on the engine and in the engine control panel. The following hardware (minimum) shall be provided on the front of the control panel; the use of the LCD display and keypad to accomplish the same function is <u>not acceptable</u>:

1. Keyed engine control mode switch (Run-Off-Auto)

2. Large, red emergency stop pushbutton

3. Generator voltage adjust potentiometer

4. Generator voltage adjust potentiometer

F. The following parameters (minimum) shall be shown on the LCD display or otherwise be indicated at the control panel:

1. Engine oil pressure

2. Coolant temperature

3. Generator output voltage

4. Generator output current

5. Generator elapsed run time

6. Generator output frequency

7. Engine run

8. Engine fail

9. Low coolant temperature

10. Pre-high engine temperature

11. Pre-low fuel level

12. Engine speed (RPM)

G. The following events (minimum) shall cause an immediate shutdown of the engine-generator set if it operating, or prevent starting if it is not operating. The specific event that causes the shutdown/prevents starting shall be shown on the LCD display or otherwise be indicated at the control panel. A reset shall be required to clear the fault and allow the unit to operate:

1. Engine coolant high temperature

2. Engine low oil pressure

3. Low fuel level

4. Engine overspeed

5. Engine overcrank

6. Engine tried to start but failed

7. Low coolant level

I. The generator control panel shall have Form C dry contacts rated 5A (minimum) at 120VAC/24VDC for the following signals:

1. Engine coolant high temperature

2. Engine low oil pressure

3. Pre-low fuel level

4. Low fuel level

5. Engine overspeed

6. Engine overcrank

7. Engine tried to start but failed

8. Low coolant level

9. Engine fail

10. Engine run

The normally closed (NC) contacts for all of the above signals (except engine run and Pre-low fuel level) shall be wired in series to provide a common "Generator System Failure" alarm for remote indication. Other contacts shall also be wired as a part of this alarm as specified elsewhere herein.

J. Engine “run” and “pre low fuel level” contacts shall be separate, independent unpowered (dry) contacts for remote indication. The remaining unpowered (dry) contacts listed above shall be normally closed (N.C.) and wired in series to provide a "Generator System Failure" alarm for remote indication.

Real-time fuel level shall be monitored and a 4-20mA signal shall be provided to indicate fuel level remaining in the tank.

All engine and alternator sensors and field devices shall be wired to the engine-generator control panel. Data from these sensors and field devices shall be available through dry contacts.

K. The controller shall provide the following status outputs for Pump Station CP monitoring:

- Generator Running (Dry Contact)
- Generator Fail (Dry Contact)
- Generator Low Fuel (Dry Contact)
- Generator Fuel Tank Level (4-20mA)

L. The controller shall be capable of accepting the following control inputs from the ATS:

- Generator Start/Stop

## 2.06 ENGINE ACCESSORIES

A. Furnish and install the engine with all accessory equipment and appurtenances which may be required for proper operation, including the following:

1. Heaviest duty available dry type air filter with a restriction indicator

2. Engine driven lubricating oil pump

3. Lubricating oil strainer

4. Heaviest duty available lubricating oil filter, bypass type, with replaceable absorbent-type elements

5. Lubricating oil cooler, water cooled

6. Lubricating oil cooling circulator pump (may be integral with main oil pump)

7. Fuel oil transfer pump

8. Fuel oil strainer

9. Heavy duty fuel oil filter, spin-on design (not replaceable absorbent element type)

10. Electronic controlled fuel injection

11. Fuel oil injection valve assemblies

12. Digital isochronous governor

13. Radiator and cooling fan

14. Jacket coolant circulating pump

15. Thermostats

16. Coolant expansion tank

17. Exhaust manifold

18. Automatic battery starting system

19. Cold starting aid engine block heaters with all controls

20. Air, fuel, and oil filters shall be sized to provide a minimum of 100 hours of operation before servicing.

21. Racor fuel-water separator

22. Nelson (or Racor) heavy-duty crankcase vapor coalesce

23. Radiator mounted fuel cooler to cool recirculated fuel before it is re-deposited into the fuel tank if recommended by the manufacturer.

24. Heavy duty coolant system and filters.

25. Lubrication oil and coolant fluid change ports shall be brought to the exterior of the enclosure for easy access by maintenance personnel. Lines shall exit the enclosure at an appropriate height to allow containers for the fluids to be placed on the platform surrounding the generators.

2.07 SOUND ATTENUATION

A. Extreme care shall be exercised in providing equipment for and setting the engine-generator in place to guard against excessive noise transmission and vibrations. Fasten to the underside of the skids seismically-rated spring type isolators.

B. The engine-generator enclosure shall be designed, furnished, and installed to reduce source noise to 67 dB(A) as measured at seven (7) meters from the enclosure.

2.08 OUTPUT CIRCUIT BREAKER

A. A molded case main line circuit breaker sized as indicated on the Drawings shall be installed as a load circuit interrupting and protection device in a NEMA 1 (gasketed) dust-tight enclosure. The circuit breaker shall be provided with adjustable long-time, short-time, instantaneous and ground fault settings. The circuit breaker shall be provided with an electronic trip unit with adjustable long-time, short-time, instantaneous, and ground fault settings. It shall operate both manually for normal operation and automatically for protection against overload or short circuits. Generator/exciter field circuit breakers are not acceptable for this service.

B. The molded case circuit-breakers described above shall be manufactured and tested in accordance with U.L. and NEMA AB1 standards. Their interrupting rating shall be suitable for the available fault current from the generator. All electrical ratings shall be suitable for the application.

C. The circuit breaker shall be mounted and oriented to provide NEC required working clearance.

2.09 MOUNTING

A. Couple the engine and generator together through a flexible, non-backlash type, all metal coupling which overcomes all normal misalignment stresses and transmits full engine torque with ample safety factor. Also provide flexible connections for piping connections.

2.10 RADIATOR

A. Provide a radiator manufactured of a non-corrosive material mounted on the engine. The radiator cooling core shall consist of plate type copper fins, solder bonded to oval brass tubes. To increase corrosion protection, fans and cores shall be solder or phenolic coated.

B. Connect the radiator to the engine internal cooling system with flexible piping.

C. The engine shall be cooled through a radiator sized to continuously maintain safe operation up to 100% of rated engine load at an outdoor ambient temperature of 110°F and an elevation of 500 feet above sea level with 50% ethylene glycol coolant. A blower type fan and low noise fan drive and controls shall be furnished. The fan and all rotating members and drive belts shall be guarded and meet OSHA standards. Proof of 110°F ambient temperature capability shall be required.

D. Coolant

1. After the cooling system is flushed and cleaned, provide an initial fill of coolant consisting of 50% ethylene glycol. A diesel coolant additive (Nalcool, Fleetguard, or equal) shall also be added to the system in the proper proportion as a corrosion inhibitor.

2. The coolant shall meet the requirements of the generator manufacturer including corrosion inhibitors provided in the coolant to protect the engine cooling system.

3. The coolant shall be premixed by the coolant manufacturer and supplied in 55 gallon drums for installation in the system.

E. The engine shall be equipped with a coolant heater. The heater shall be in accordance with the following:

1. Unit mounted thermal circulation type coolant heaters with coolant recirculation pump shall be furnished to maintain engine jacket coolant temperature as recommended by manufacturer in an ambient temperature of minus 20°F. The heaters shall be 240 VAC, single phase, 60 hertz, thermostatically controlled as manufactured by Kim Hotstart, or equal. Heaters shall be 3 KW, minimum.

2. The heater shall be of sufficient capacity to keep the coolant at a suitable temperature for trouble-free starting.

3. Each heater shall be provided with a suitable contactor to automatically disconnect the heater when the engine is started.

2.11 ENGINE STARTING SYSTEM

A. Provide an engine starting system complete with battery charger and batteries.

B. The charger shall be an automatic battery charger, 20 A min, current limited, ±2% voltage regulation, ±10% line voltage variation, equalizing timer, DC voltmeter, and DC ammeter. Provide a 0-24 hour equalize timer and a Form C dry contact rated 5A (minimum) at 120VAC/24VDC to indicate a low battery alarm condition. The normally closed part of this contact shall be also be wired as part of the common "Generator System Failure" alarm specified elsewhere herein.

C. Starting batteries shall be sealed, lead-acid type rated 12 volts, configured for 24V starting, having adequate capacity for rolling the engine for five (5), ten (10) second cycles without starting, and then continue to operate the control devices in the generator control panel. The batteries shall be mounted on a suitable non-corrosive rack. Batteries shall have battery cables with lugs and shall be provided with lugs for connection to the battery charger. Batteries shall fit alongside the engine (batteries installed under the generator are not acceptable) where they are easily accessible and the cable length to the starter motor is minimized.

D. The engine starting shall be automatically controlled through the generator control panel. Starting means shall be via 24VDC starting motor(s) with integral starting solenoid and

contacts. The engine shall have a 24 volt battery charging generator with an automatic charge rate regulator.

2.10 EXHAUST SILENCER AND PIPING

A. Furnish and install an exhaust silencer mounted within or exterior to the generator enclosure dependent on generator size and manufacturer's standards. Silencers mounted outside the generator enclosure shall be 316 stainless steel interior and exterior. The silencer system shall be designed, furnished, and installed to prevent moisture and condensation from corroding the silencer. Silencers mounted within the generator enclosure shall be insulated using a calcium silicate material covered by a brushed aluminum skin. All exterior components of the exhaust silencer system shall be of 316 stainless steel.

B. Silencers shall be of critical type and sized to produce a high degree of silencing. Reference the sound attenuation requirements specified herein.

C. Connect the silencer to the engine exhaust manifold with a high corrosion and temperature resistant stainless steel flexible convoluted exhaust pipe. Use flange-type connections. Provide a taper-cut tail pipe complete with rain cap to exhaust the gases to the atmosphere.

D. The silencer (if installed inside), exhaust piping, and expansion fittings, including collector box, shall be completely covered with a removable insulation blanket in order to protect operating personnel and to reduce noise. Insulation shall be of composite fiberglass and stainless steel construction capable of withstanding 1200°F continuously. The insulation blankets shall be tailored and custom fabricated to fit the contours of the manifolds. Average weight of the insulating blanket shall be 1.5 psf. Insulation shall conform to MIL-1-16411D, Type II and shall be custom fabricated to fit the contours of the components.

2.11 WIRING

A. Manufacturer shall furnish and install all internal wiring within the engine-generator set package. All external wiring between the generator and engine-generator control panel, the automatic transfer switch and all other components of the standby power system, including conduit and connection, shall be furnished and installed by the Contractor.

2.12 AUTOMATIC TRANSFER SWITCH

A. Furnish and install an automatic transfer switch as indicated on the Drawings and specified in Section 16496, Automatic Transfer Switch. The switch and its operation shall be considered to be part of the standby generator system.

2.13 BASE MOUNTED FUEL TANK

A. The generator set shall be supplied with a U.L.-142 listed base mounted fuel tank of sufficient capacity to operate the engine-generator set at 50% load for a minimum of 24 hours. The tank, painted in a color as selected by the Engineer, shall be fabricated from steel with a rupture basin and leak detector system. The alarm and indicator for the leak detection shall be mounted adjacent to the generator control panel and a Form C dry

contact rated 5A (minimum) at 120VAC/24VDC for remote indication of a fuel leak condition shall be provided. The normally closed part of this contact shall be also be wired as part of the common "Generator System Failure" alarm specified elsewhere herein. The containment tank top shall be capped to allow water run off.

B. A level device shall also be furnished and installed to provide the generator control panel with indication of pre-low fuel tank level and low fuel tank level. The low fuel tank level shall be set at an elevation to prevent the fuel level from dropping below the fuel pickup piping in the tank. The pre-low fuel level shall be set at an elevation to activate when only 6 hours of fuel for full load operation remains in the tank.

C. The tank shall be supplied with all necessary fuel supply, return, vent, and fill fittings and a fuel level gauge. The level gauge shall be easily accessible from outside the enclosure. The vent line shall be piped to the outside and be equipped with a fill whistle. A fill connection shall be provided through the enclosure wall. Provide a valve that automatically closes the fuel fill inlet when the tank level reaches 95% of its capacity.

E. The underside of the tank shall not be in contact with the mounting surface (concrete pad).

F. The tank shall be equipped with an immersion heater to keep the fuel at the inlet to the engine within an acceptable temperature range. The heater shall be wired for operation on a 240 VAC, single-phase, 60 hertz power source.

G. A fuel level monitoring device shall be provided to monitor the real-time fuel level of the tank. The monitoring device shall have a local display that indicates the fuel level in gallons, and shall also provide a 4-20ma analog output.

2.15 WEATHERPROOF ENGINE - GENERATOR ENCLOSURE

A. Furnish and install an outdoor, weather-protective housing. The housing shall be furnished complete with a full sub-base floor resulting in complete enclosure. The enclosure shall be factory-assembled to the engine-generator set base and radiator cowling. Lifting eyes shall be provided. Housing shall provide ample airflow for generator set operation. The housing shall be constructed of 12 gauge (minimum) aluminum or 14 gauge (minimum) galvanized steel, reinforced to be vibration free in the operating mode. The housing shall have hinged access doors where required for regular maintenance or access to devices requiring a minimum working clearance. Each door shall have at least two latch-bearing points, be gasketed, and shall be lockable. Roof shall be peaked to allow drainage of rain water. Unit shall have sufficient guards to prevent entrance by small animals. Unit shall have engine coolant and oil drains outside the unit to facilitate maintenance. Each drain line shall have a high quality valve located near the fluid source.

B. A “Skin-tight” housing shall be provided. No walk-around access is required within the enclosure.

C. Enclosure shall be sound attenuated to provide sound level as specified herein. The enclosure shall draw air in through the alternator end through a downward facing intake hood. The cooling air shall be pushed out through the radiator end vertically through an upward facing discharge hood. Designs that allow exhaust air to be forced out of the

enclosure horizontally shall not be allowed.

D. The enclosure shall be primed for corrosion protection and finish painted in a color selected by the Owner as follows:

1. For steel enclosures:

a. The galvannealed steel enclosure shall be cleaned, dried and degreased prior to painting.

b. All panel seams, bottom perimeter, and corner flashings shall be caulked using a pure urethane caulk.

c. The enclosure surfaces shall be cleaned and etched to promote paint adhesion.

d. The appropriate coats and quantities of prime paint shall be applied to the surfaces of the unit. Either a urethane prime paint coating (Diamond Vogel, Stratum Urethane Prime, 2 Component) shall be applied to a 1-2mills dry film thickness or a high build epoxy paint coating (PPG, HBE Epoxy Prime, 2 Component) shall be applied to a 1.5-3mils dry film thickness.

e. Finish paint shall be applied using proper application methods and equipment within the prime paint re-coat window. Recommended top coats are acrylic enamel finish paint such as PPG ALK-200, or equal.

f. Structural ferrous steel materials such as bases and mounting skirts that attach to the galvannealed enclosure shall be cleaned and shop primed after welding.

2. For aluminum enclosures:

a. Thoroughly clean, de-grease, and etch all surfaces by washing the unit down with “Aluma-prep” aluminum material prepping solution, or by adequate mechanical abrasion.

b. Using proper application methods and equipment, apply Tnemec Series 66, 2-part, hi-build, catalyzed, epoxoline prime paint to 4-6 mils DFT. The coating shall cover all surfaces to promote adhesion to the substrate material and to provide a smooth surface for finish painting.

c. Ensure the primed surface is clean and dry.

d. Finish paint shall be applied using proper application methods and equipment within the prime paint re-coat window. Recommended top coats are acrylic enamel finish paint such as PPG ALK-200, or equal.

E. All hardware (nuts, bolts, screws, washers, etc) that is installed on the exterior of the generator enclosure shall be stainless steel. Galvanized steel hardware is not acceptable.

F. LED lighting shall be provided in sufficient quantity to maintain 20 foot-candles of illumination at floor level and shall be suitable for operation in cold weather. Interior lighting shall be controlled by 3-way light switches located at each door. Reference Section 16141.

G. Convenience receptacles shall be furnished at each door within the enclosure. Receptacles shall be 125V, 20A, two-pole, three wire grounded type. Reference Section 16141.

H. Conduit and wire shall be in accordance with Sections 16111 and 16123, respectively.

I. Conduit furnished and installed within the enclosure may be electrical metallic tubing and supported using one-hole conduit straps. Conduit fittings shall be steel compression type.

J. All air intake louvers shall be furnished with rain guards or designed to eliminate water intrusion to the interior of the enclosure when the generator is operating at full load (maximum airflow) during rain events.

2.16 PAINTING

A. All ferrous metal surfaces, except stainless steel, shall be cleaned and painted with a rust inhibiting primer and manufacturer's standard finish paint and shall be suitable for the operating temperature.

## PART 3 -- EXECUTION

3.01 INSTALLATION

A. The standby generator system shall be furnished and installed as indicated on the Drawings and as recommended by the equipment manufacturer.

B. The initial filling of the fuel storage tank shall be provided by the Contractor. Fuel tank shall be filled to its full capacity. At the conclusion of all field testing, the Contractor shall fill the fuel storage tank back to its full capacity. Fuel shall be ultra-low sulfur diesel in accordance with ASTM D-975. Fuel shall be new and free from contaminants and water.

3.02 SERVICES OF MANUFACTURER'S REPRESENTATIVE

A. The Contractor shall provide the services of a qualified generator manufacturer's factory-trained technical representative who shall adequately supervise the installation and of all equipment furnished under this Contract. The manufacturer's representative shall certify in writing that the equipment has been installed in accordance with the manufacturer's recommendations. No further testing or equipment startup may take place until this certification is accepted by the Owner.

B. The manufacturer's technical representative shall perform all startup and field testing of the generator assembly as specified herein.

C. The Contractor shall provide training for the Owner's personnel. Training shall be conducted by the manufacturer's factory-trained representative who shall instruct Owner's personnel in operation and maintenance of all equipment provided under this Section. Training shall be provided for two (2) sessions of four (4) hours each. Training shall not take place until after the generator has been installed and tested. Training shall be conducted at times coordinated with the Owner, at the same time as the pump station commissioning.

D. The services of the manufacturer's representative shall be provided for a period of not less than as follows:

1. One (1) trip of two (2) working days during installation of the engine-generator set.

2. One (1) trip of one (1) working day to perform startup of the engine-generator set.

3. One (1) trip of two (2) working days to perform the field testing of the engine-generator set.

E. Any additional time required to achieve successful installation and operation shall be at the expense of the Contractor.

3.03 TESTING

A. All tests shall be performed in accordance with the manufacturer recommendations, the requirements of the General Conditions, and Division 1. The following minimum tests are required:

1. Shop Tests

a. Fully test the engine-generator set with all accessories in the manufacturer's plant before shipment. Tests shall be conducted through the use of balanced, three-phase, dry-type, resistive load banks.

b. Record complete test data for frequency, amperes, volts, power factor, exhaust temperature, coolant temperature, and oil pressure.

c. The manufacturer shall conduct a shop test run of at least six (6) consecutive hours for the set under the following conditions of load, in the following order:

2 hours - full load
1 hour - 3/4 load
1 hour - 1/2 load
1 hour - 1/4 load
1 hour - no load

d. Fuel, lubricants, and other fluids as required for the shop tests shall be furnished by the manufacturer.

2. Field Tests

a. Field tests shall be performed by the generator manufacturer's technical representative. The Contractor shall obtain from the manufacturer and submit a detailed field test plan and procedures documenting the intended field test program.

b. In the presence of the Engineer and Owner, the representative shall inspect, adjust, and test the entire system after installation and leave in good working order. Field tests specific to each generator shall be conducted after the entire engine-generator system is installed including, but not limited to, the following: diesel fuel tanks including leak detection, exhaust silencer, radiators, enclosures, batteries, and all other equipment included in the complete system.

c. Field test the generator enclosure to ensure the enclosure performs as specified herein. The generator enclosure field tests shall include water tests to confirm the enclosure does not leak and that the air intake louvers eliminate water intrusion to the interior of the generator enclosure when the generator is operating at its full load capacity (maximum airflow). A garden hose shall be used to simulate falling rain for this test. Water supply and garden hose will be provided by the Owner for this test.

d. Field test, as far as practicable, all control, shutdown, and alarm circuits. Document the successful completion of these tests as witnessed by the Owner and the Engineer.

e. Generator load tests shall be conducted through the use of balanced, three-phase, dry-type, reactive (0.8 power factor) load banks. Tests shall be conducted in the presence of the Owner and Engineer. Tests shall be the typical manufacturer's recommended tests.

Record complete test data for frequency, amperes, volts, power factor, exhaust temperature, coolant temperature, and oil pressure every 15 minutes during the test. If any failures, malfunctions, and/or shutdowns occur during this test, the problems shall be fixed and the test shall be restarted.

f. After successful completion of the load bank tests, the generator system shall then be operated for a minimum of four (4) hours with pump station loads during a time period when the pump station is operating at average demand. The same data shall be recorded at 15 minute intervals for this load test as for the load bank test.

g. After the completion of the automatic transfer controls startup (see Section 16496) and the load tests listed above, the generator and automatic transfer controls shall be tested as an overall system in the presence of the Engineer and Owner. Utility service outages shall be **simulated** to allow automatic controls to perform the transfers, transfers shall not be manually initiated. As a minimum, the generator and automatic transfer tests shall be performed as follows:

- Three (3) open transition transfers from the utility service to the generator and then back to the utility service under the then current pump station operating load.

It is the intent that these tests take place utilizing pump station loads. If the system cannot be fully loaded as required by the pump station loads, the manufacturer shall connect a reactive load bank as needed to test the system under the loads described above. If any failures, malfunctions, and/or shutdowns occur during any of the transfer tests listed above, the problems shall be fixed and the test shall be restarted. Each test shall not be considered complete until the generator system has performed the required number of transfers consecutively without any failures or malfunctions. During the transfer testing above, the loads shall remain on the utility or generator source for at least five (5) minutes in between transfers.

h. The Contractor shall collect a sample of engine oil from each engine for analysis after the start-up and testing has been completed. The sampling method shall be of the atomic absorption spectrophotometry method and be accurate to within a fraction of one part per million for the following elements:

- Iron
- Chromium
- Copper
- Aluminum
- Silicon
- Lead

The sample shall also be tested for the presence of water, fuel dilution, and coolant.

The oil samples shall be analyzed at the generator set Manufacturer's facility by factory trained personnel. Independent laboratories not a part of the engine supplier's facility are disallowed as to conformance with this specification. Immediate notification of critical results shall be provided to the Owner when the analysis shows any critical reading.

i. All fuel, lubricants, and other fluids required to complete all field tests shall be paid for by the Contractor.

3.04 PAINTING

A. Prior to final completion of the work, all metal surfaces of the equipment shall be cleaned thoroughly, and all scratches and abrasions shall be retouched with the same coating as used for factory finishing coats.

- END OF SECTION -

SECTION 16902

ELECTRIC CONTROLS AND RELAYS

## PART 1 -- GENERAL

### 1.01 THE REQUIREMENT

A. The Contractor shall furnish, install, test, and place in satisfactory operation all electric controls and relays as specified herein and indicated on the Drawings.

B. Electrical control and relay systems shall be assembled using NEMA rated components. Components designed and built to International Electrotechnical Commission (IEC) standards are not recognized. Equipment designed, manufactured and labeled in compliance with IEC standards is not acceptable.

C. Motor control circuits shall be wired in accordance with the requirements specified herein or indicated on the Drawings.

D. Reference Section 16000, Basic Electrical Requirements and Section 16195, Electrical Identification.

E. The Contractor shall furnish and install, as specified herein and indicated on the Drawings, all motor control components and wiring for all motor-operated equipment furnished under this Section and all other Sections as indicated. The Contractor shall review the entire Contract Documents to be totally familiar with his responsibilities.

F. The Contractor shall furnish and install all external power and control wiring to control panels of prewired packaged equipment, unless indicated otherwise.

G. Control wiring requirements are indicated in electrical schematics and descriptions on the Drawings, in functional control descriptions which appear in Section 11130 of these Specifications, and in equipment manufacturer's equipment data. The Contractor shall furnish and install all control wiring in accordance with these Contract Documents. The Contractor shall provide all control circuits and wiring for a particular item of equipment in accordance with requirements as set forth by the manufacturer of the particular item of equipment.

H. As specified herein and indicated on the Drawings, furnish and install instrumentation wiring and connections to instrumentation equipment furnished under all Contracts of this Specification. Unless indicated otherwise, motor control switches, pilot lights, relays, and other control equipment for mounting in instrumentation panels shall be furnished, installed, and wired by the Contractor.

I. Where pumps provided by others are furnished with solenoid valves or other devices for control, the Contractor shall wire these valves or devices.

J. Unless otherwise specified herein or indicated on the Drawings, motor controllers shall be wired to drop out and remain dropped out on loss of power to the line side of the controller.

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Operator action shall be required to restart the motor unless the motor is intended to automatically restart.

K. Motor control components and control wiring shall conform to NEMA Specifications ICS-1970 (Revised, 1975), Industrial Controls and Systems.

L. Where devices are installed on the doors of NEMA 4, 4X, or 3R enclosures, devices shall be selected and installed to maintain the NEMA rating of the enclosure.

M. Wiring in all starters, panels, junction boxes, and similar equipment shall be brought out to numbered terminal strips for interconnection. The Contractor shall be responsible for documenting terminal numbers for all starters, controls, panels, and similar equipment provided under the Contract. At the completion of the project, the Contractor shall submit a complete set of record drawings showing and/or listing all terminals in boxes, panels, starters, and similar equipment in a single, complete bound package for the equipment and control supplied under the Contract. Reference the General Conditions, Section 01300 - Submittals and Section 01700 - Project Closeout.

N. The Contractor is responsible for coordinating the electrical work under the Contract with all equipment starters, controls, and instruments provided by others. The Contractor shall verify and coordinate with process equipment power supply and voltage, process equipment control power supply and voltage, and details of installation and interconnection. Coordination shall include distribution of approved electrical shop drawings to the General Contractor's equipment suppliers.

O. Electrical control schematic diagrams drawn using a ladder-type format in accordance with JIC standards shall be submitted for all electrical equipment which is being provided under the Contract.

P. Record drawings shall be provided in accordance with requirements in the General Conditions, Section 01300 - Submittals, and Section 01700 - Project Closeout. One complete set of record wiring diagrams encased in plastic or plexiglass envelopes shall be provided for each starter, panel, and similar equipment. The diagrams shall include wire color codes showing connections from numbered terminal blocks to external equipment.

Q. Where space or strip heaters are provided within the enclosures for electrical equipment, the Contractor shall make connections to these heaters from an appropriate power source and operate the heaters with temperature control as necessary until the equipment is installed and operated according to its intended use.

R. Control stations shall be furnished and installed at each motor and at all other controlled devices (e.g. solenoid valves) as specified herein and indicated on the Drawings.

1.02 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the General Conditions and Section 01300, Submittals, the Contractor shall obtain from the equipment manufacturer and submit the following:

1. Shop Drawings.

2. Operation and Maintenance Manuals.

B. Each submittal shall be identified by the applicable specification section.

1.03 SHOP DRAWINGS

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete or illegible submittals will be returned to the Contractor without review for resubmittal. The letter and performance affidavit described above must be included in the first submittal.

C. Shop drawings shall include but not be limited to:

1. Product data sheets.

D. The shop drawing information shall be complete and organized in such a way that the Engineer can determine if the requirements of these Specifications are being met. Copies of technical bulletins, technical data sheets from "soft-cover" catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items the Contractor intends to provide are acceptable and shall be submitted.

1.04 OPERATION AND MAINTENANCE MANUALS

A. The Contractor shall submit operation and maintenance manuals in accordance with the procedures and requirements set forth in the General Conditions and Division 1.

1.05 TOOLS AND SUPPLIES

A. The electrical control and relay systems and accessories shall be furnished with all special tools necessary to disassemble, service, repair, and adjust the equipment. All spare parts as recommended by the equipment manufacturer shall be furnished to the Owner by the Contractor.

PART 2 -- PRODUCTS

2.01 CONTROL COMPONENTS

A. Pilot Devices

1. Pushbuttons (PB) and selector switches (SS) shall be Type E34 as manufactured by Eaton Corporation, Type 3SBO as manufactured by Siemens Energy and Automation Inc., General Electric Company Type CR104P, The Square D Company equivalent, or Allen-Bradley equivalent. Pushbuttons and selector switches shall be 30.5 mm, heavy-duty, oil tight NEMA 4X corrosion resistant with legend plates as specified herein, indicated on the Drawings, or otherwise directed by the Engineer. Legend plates shall be plastic, black field (background) with white lettering. Pushbuttons and selector switches shall be non-illuminated. Pushbuttons shall

include a full guard. Panic stop/alarm pushbuttons shall be red mushroom type with manual-pull release.

2. Pushbuttons and selector switches for all electrical equipment shall be of the same type and manufacturer unless otherwise specified herein or indicated on the Drawings.

3. Pushbuttons, selector switches, and other pilot devices for pump control panels shall be as specified herein and in the functional control descriptions which appear in Section 11130, and as shown on the Drawings.

4. Engraved nameplates shall be securely fastened to the front of each pushbutton station, disconnect switch, and motor starter remotely located from the motor control center. If adequate space is not available, the nameplate shall be mounted below the push button station. Nameplates shall be as specified in Section 16195, Electrical Identification. Identify all switches, control stations, and motor controllers as to their respective equipment.

5. Pilot lights shall be Type E34 as manufactured by Cutler- Hammer, Type 3SBO as manufactured by Siemens Energy and Automation Inc., General Electric Company Type CR104P, The Square D Company equivalent, or Allen-Bradley equivalent. Pilot lights shall be of the proper control voltage, LED type, push to test, heavy-duty, corrosion-resistant NEMA 4X with legend plates as specified herein, indicated on the Drawings, or otherwise directed by the Engineer. Legend plates shall be plastic, black field (background) with white lettering. Pilot light lens colors shall be as follows:

   Red - "Run", "On", “Open”
   Green - "Off", “Closed”
   Amber - "Alarm", "Fail"
   White - “Control Power On”

6. Pilot lights for all electrical panels shall be of the same type and manufacturer unless otherwise specified herein or indicated on the Drawings.

7. Pilot lights for pump control panels shall be round with custom engraved legend plates for each pilot light.

B. Control and Timing Relays

1. Control Relays (CR) shall be Type DP3 as manufactured by Eaton Corporation, Type CR420 as manufactured by General Electric Company, Potter-Brumfield equivalent, The Square D Company equivalent, Siemens Energy and Automation Inc. equivalent, or Allen-Bradley equivalent. Relays shall be general purpose plug-in type with coil voltage as shown on the Drawings and sealed 10 ampere contacts. All relays shall have three SPDT contacts rated 120/240 VAC and 28 VDC minimum. Machine tool relays shall be provided when the contact burden exceeds 10 amperes. The relays shall be furnished with an internal pilot light for positive indication of coil energization. The relays shall be furnished with a manual operator to manually switch the contacts to simulate normal operation. Miniature type or "ice cube" relays are not acceptable.

2. Timing Relays (TR) shall be the general purpose plug-in type, Type TR as manufactured by Eaton Corporation, Type TUC as manufactured by Diversified Electronics The Square D Company equivalent, Siemens Energy and Automation Inc. equivalent, or Allen-Bradley equivalent. Timing relays shall be electronic type with 120 VAC coils unless otherwise specified or indicated on the Drawings. Timers shall be provided with two SPDT timed output contacts. Contact ratings shall be the same as for control relays as specified above.

C. Miscellaneous

1. Selected motors are indicated as requiring elapsed time indicators. Provide Eagle Signal Type HK210A6, General Time Catalog #ED27NR, Allen-Bradley equivalent, or equal, elapsed time indicators for 120 VAC volt operation mounted flush in the respective motor starter compartment door. Where clearance is not obtainable for compartment door closing, mount timers in a separately mounted enclosure, with each timer identified. Wire elapsed time indicator to operate when the respective motor operates.

2 Terminal blocks shall be assembled on non-current carrying galvanized steel DIN mounting rails securely bolted to the enclosure or cabinet subpanel. Terminals shall be tubular screw type with pressure plate for wire size #22 - #8 AWG.

3. Power terminal blocks shall be single tier with a minimum rating of 600 volts, 30A. Signal terminal blocks shall be single tier with a minimum rating of 600 volts, 20A. Separate terminal strips shall be provided for each type of power and signal used within each cabinet. There shall be a sufficient quantity of terminals for the termination of all spare field conductors.

4. Terminals shall be marked with a permanent, continuous marking strip. One side of each terminal shall be reserved exclusively for incoming field conductors. Common connections and jumpers required for internal wiring shall not be made on the field side of the terminal. Subject to the approval of the Engineer, a vendor's pre-engineered and prefabricated wiring termination system may be acceptable.

The terminal blocks shall be as manufactured by Phoenix Contact, Inc., Wieland, Inc., or equal.

## PART 3 -- EXECUTION

### 3.01 CONFIGURATION OF CONTROLS AND EQUIPMENT

A. All controls including wiring, control switches, pushbuttons, indicating lights, control interlocks and similar devices, shall be provided at the control voltages specified herein or indicated on the Drawings. Each motor starter shall be provided with a control power transformer mounted in the starter unit. Primary wiring to the control power transformer shall be tapped to two (2) poles on the load side of the circuit breaker or fusible switch. Both primary wires shall be fused with 10- ampere, slow-blow fuses. The fuse on the ungrounded secondary side shall be capable of handling 100 percent to 125 percent of the rated control transformer secondary current. Control power transformers shall be provided

with volt-ampere (VA) ratings equal to a minimum of 125 percent of the volt-ampere (VA) load connected to the transformer.

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

C. All equipment shall be designed to operate on a 60 Hz alternating current power source at a nominal 117 volts, plus or minus 10 percent, except where specifically noted. All regulators and power supplies required for compliance with the above shall be provided.

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

E. Materials and equipment used shall bear a U.L. label wherever such labeling of equipment and materials are available.

F. Unless otherwise specified or indicated on the Drawings, all equipment shall be designed, furnished, and installed so that in the event of a power interruption, the equipment must be restarted manually after a power failure.

G. All power terminals shall be insulated and identified.

H. All instruments shall operate at 10 to 125 degrees F unless otherwise specified.

I. Internal wiring within all starters, panels, instruments, junction boxes and similar equipment, shall be brought out to numbered terminal strips for interconnection and field wiring.

J. All control components shall be mounted in a manner that will permit servicing, adjustment, testing, and removal without disconnecting, moving, or removing any other component. Components mounted on the inside of panels shall be mounted on removable plates and not directly to the enclosure. Mounting shall be rigid and stable unless shock mounting is required otherwise by the manufacturer to protect equipment from vibration. Component's mounting shall be oriented in accordance with the component manufacturer's and industries' standard practices. All internal components shall be identified with suitable plastic or metal engraved tags attached with drive pins adjacent to (not on) each component identifying the component in accordance with the Drawings, Specifications, and supplier's data. Terminal strips, relays, timers, and similar devices shall not be installed on the rear of the panel/cabinet doors or on the side walls of panel/cabinet interiors unless otherwise indicated in the Contract Documents.

K. The functional control descriptions which appear in Section 11130 indicate interconnections between panels, instruments, and similar equipment. Unless otherwise noted, the Contractor shall provide all interconnecting wiring and conduit for complete control systems. The Contractor shall make all connections to equipment devices, instruments, and all components requiring electrical connection.

L. The shield on each instrumentation cable shall be continuous from source to destination and shall be grounded as directed by the manufacturer of the instrumentation equipment. In no

case shall more than one ground point be employed for each shield. The ground point shall be as specified in Division 17. All analog control functions shall utilize 4-20 mADC control signals, unless otherwise specified. All analog transmission shall take place within shielded twisted cables which are not susceptible to interference or noise.

M. Lightning/surge protection shall be provided to protect the instrumentation and control system from induced surges propagating along the signal and power supply lines. The protection systems shall be such that the protective level shall not interfere with normal operation, but shall be lower than the instrument surge withstand level, and shall be maintenance free and self-restoring. Equipment shall be housed in a suitable metallic case, properly grounded. Ground wires for all surge protectors shall be connected to a good earth ground and, where practical, each ground wire run individually and insulated from each other. These protectors shall be mounted within the enclosure or in a separate NEMA 4 junction box coupled to the enclosure.

N. Reference Division 17 - Control and Information Systems for additional information regarding lightning/surge protection requirements.

3.02 FIELD TESTS

A. The Contractor shall conduct field tests prior to operation of the equipment. The Engineer shall witness all field testing. Field testing shall be conducted at a time approved by the Engineer. Field tests shall be conducted for all hardware components and shall include a functional check of all items. Field tests shall include a functional check of all instruments and control equipment. All equipment shall be connected and fully operational for field testing. Field tests shall demonstrate that the controls perform according to the Contract requirements and that all equipment, valves, switches, controls, alarms, interlocks, indicating lights, and similar equipment function properly. Based on the results of field tests, the Contractor shall make any required corrections to equipment and controls and shall make any adjustments required to the control logic and control settings to achieve the specified operation or operation otherwise directed by the Engineer. Field tests shall be conducted for the full range of operating modes and conditions specified and as directed by the Engineer. The Contractor shall make modifications and adjustments to the controls as directed by the Engineer for optimizing operation of the overall system. All costs in connection with field tests of equipment provided under the Contract, shall be borne by the Contractor. The Contractor shall be fully responsible for the proper operation of all motor starters and controls during the tests.

- END OF SECTION -

SECTION 17000

CONTROL AND INFORMATION SYSTEM
SCOPE AND GENERAL REQUIREMENTS

PART 1 -- GENERAL

1.0 THE REQUIREMENT

A. This specification section is intended to ensure a complete, functional and tested SCADA communications system. This section complements the SCADA component requirements stated in Section 11130 Submersible Non-Clog Pumps, such that many of the components for the SCADA system are required to be provided to the Pump Supplier. The Pump Supplier will incorporate some SCADA components into an integrated freestanding, outdoor Pump Control Panel. The Contractor shall coordinate and integrate SCADA equipment "outside" of the Pump Control Panel, such as antenna pole, conduit, grounding, coaxial cable, terminations and antenna, etc., and labor for installing such equipment and testing – into his bid. The end result being that SCADA equipment inside the Pump Control Panel, and SCADA equipment outside the Pump Control Panel, all labor and testing for the complete system are covered by the Contractor's bid.

B. The Owner shall be responsible for the integration of the new pump station signals and alarms in their existing SCADA system located at Berkeley County Water & Sanitation. This shall include updating the receiving PLC database, creating new or modifying existing HMI graphics to include the pump station, update alarm pages, trends, reports and data historian, as required, to include the new pump station.

1.1 SECTION INCLUDES

A. Antenna

B. Enclosures

C. Appurtenances

1.3 RELATED SECTIONS

A. Section 16000 – General Electrical Requirements.

B. Section 11130 – Submersible Non-Clog Pumps.

C. Divison 17.

1.4 SUBMITTALS

A. Section 01300 - Submittals.

B. Shop Drawings: Indicate front and side views of equipment, and enclosure if provided, with overall dimensions and weights shown; wiring and connection locations and requirements.

C. Product Data: Submit catalog sheets showing wiring, equipment size, voltage and current ratings and size of switching and overcurrent protective devices, short circuit ratings, environmental requirements, dimensions, and enclosure details.

D. Test Reports: Indicate Path Study procedures and test results. Provide inspection procedures for SCADA equipment and field communications performance test and results.

1.4 CLOSEOUT SUBMITTALS

A. Section 01700 - Execution Requirements: Closeout procedures.

B. Operation and Maintenance Data: Submit instructions for operating equipment. Include routine preventive maintenance or testing schedule.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Section 01600 - Product Requirements: Product storage and handling requirements.

B. Store in clean, dry space. Maintain factory wrapping or provide additional cover to protect units from dirt, water, or other harsh environments.

C. Follow manufacturer's and supplier's recommendations regarding handling and storage at all times prior to placing equipment in service.

1.6 QUALITY ASSURANCE

A. Technical Services: Provide service of supplier's service technician as required.

PART 2 PRODUCTS

2.1 SYSTEM

A This specification requires provision of a completely working remote station. All necessary hardware, software, programming, material, labor and installation services shall be provided.

B All control signals, status signals, alarm and or process variable data generated by the RTU shall be transmitted and received between the central location and the remote site via the SCADA system. The required I/O signals to transmit shall be obtained from the project design drawings and the Owner.

C Any additional components, whether specified herein or not, shall be provided for a completely operating pump station by this contractor.

2.2 COORDINATION

A. The antenna, feedline coaxial cable, conduit, bonding/grounding kit and wood antenna pole shall be provided and installed by this Contractor. Materials may be obtained from suppliers and per equipment manufactuer's recommendations.

B. Contractor shall furnish and install all equipment exterior to the Pump Station Control Panel as shown on the Contract Drawings. This includes but is not limited to all equipment specified herein and in other sections of Divison 17.

2.3 SYSTEM COMPONENTS

A. Antenna:
   1. The Antenna will be high gain, 200 Watt power handling, directional YAGI, suitable for use with the radio frequency selected.
   2. Antenna shall be constructed with 0.25 in., 6061-T6 Aluminum rod. Boom shall be 1 in or 3/4" constructed of same material. Hardware shall be stainless steel. Mounting is to wood utility pole.
   3. The Owner will determine the correct frequency based upon his system needs. Therefore, the contractor shall consult with the Owner prior to selecting the particular model number.
   4. Antenna shall be Cushcraft PC457N for 400 MHz frequency operation. These model numbers shall be confirmed by radio supplier and may change.

B. Appurtenances
   1. Andrew Heliax LDF4-50A antenna feedline coaxial cable. Type and diameter as specified by the radio supplier and length as required.
   2. Coaxial cable connectors shall be of the highest quality. Provide to the radio supplier who shall install with meticulous care to avoid all possibilities of moisture intrusion, loose connections or any other weaknesses causing excessive signal losses or distortion.
   3. The bonding/grounding kit shall be type WGK-# grounding kit. This kit shall be bonded to the coaxial cable metallic shield, to the raceway grounding bushing and the ground rod at the wooden antenna pole ground.
   4. Antenna pole: 60 foot, class 3, CCA pressure treated, southern yellow pine, utility grade wood pole. Pole shall be provided with a pole ground, #4 bare copper stapled to pole as indicated on the attached installation detail. Comply with all local ordinances, codes and regulations regarding wood pole length, transportation, and permitting. Contractor bears complete responsibility to comply. Notify Engineer and Owner of any changes.

C. Single-Source Responsibility: All principal system components (except wood pole) are available, and shall be provided as, a " ready to install" package.

D. Compatibility: System shall be fully compatible with other components of the Owner's existing SCADA system. Proper communications shall be established. Contractor shall perform functional testing to the Owners' satisfaction.

PART 3 EXECUTION

3.1 UNIT PLACEMENT

A. Ensure that SCADA equipment is properly located on site. Obtain Owner's approval prior to final antenna pole placement. Ensure SCADA equipment components mounted inside the pump control panel are installed per equipment manufacturer's instructions.

B. Properly locate and erect wood antenna pole as shown on Contract Drawings.

3.2 INSTALLATION

A. Install all components in accordance with the instructions of the manufacturer and supplier.

B. Provide 2" conduit containing antenna cable from Pump Control Panel to three (3) feet above grade at bottom of wood antenna pole. Use rigid metal conduit for 3-foot vertical run at base of pole. Provide sweeping elbow below grade and terminate conduit with threaded grounding bushing to bond with coax ground kit and grounding electrode. Do not violate the minimum bending radius of the antenna cable as specified by the manufacturer. Do not crimp the coaxial conductor. Contractor shall replace entire Coax line if damaged.

C. Terminate conduit on antenna pole using properly sized weatherproof CGB (cord grip) type fitting or other manufacturer approved fittings.

D. Use insulated straps to secure the coaxial antenna cable to the wooden antenna pole. Install per manufacturer's recommendations, taking care not to damage the cable jacket.

E. Contractor shall install antenna, upper connector and waterproof kit, heliax and grounding/bonding kit in complete coordination with work provided by RCC, Inc. Additionally, the wood antenna pole, all raceway and raceway supports shall be provided and installed by the Contractor.

3.3 STARTUP AND TESTING

A. Supplier's service technician shall visit the site, test and confirm that the system was installed in accordance with the instructions of the manufacturer and supplier.

B. Any damaged components, cable, or high losses found or discovered through testing will be repaired by the Contractor at no additional cost to the Owner. Contractor shall replace entire Coax line if damaged. Replacement coaxial cable and fittings shall be re-tested for signal strengths and loss.

- END OF SECTION -

# SECTION 17560

# SURGE PROTECTION DEVICES

## PART 1 -- GENERAL

### 1.01 THE REQUIREMENT

A. The Contractor shall furnish, install and place in satisfactory operation the surge protection devices (SPDs) as specified herein and as shown on the Drawings.
B. Refer to *16449- Pump Control System* Section 2.1 for Pump Control System Overview

### 1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17000 – Control and Information System Scope and General Requirements

### 1.03 GENERAL INFORMATION AND DESCRIPTION

A. All surge protectors of each type provided under this Contract shall be furnished by a single manufacturer.

## PART 2 -- PRODUCTS

### 2.01 ELECTRICAL TRANSIENT PROTECTION, GENERAL

A. All electrical and electronic elements shall be protected against damage due to electrical transients induced in interconnecting lines from lightning discharges and nearby electrical systems.

B. Manufacturer's Requirements: All surge protection devices shall be manufactured by a company that has been engaged in the design, development, and manufacture of such devices for at least 5 years. Acceptable manufacturers shall be Phoenix Contact, Edco, Transtector, or equal.

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C. Surge protection device installations shall comply with UL 94, the National Electric Code (NEC), and all applicable local codes.

D. Surge protection devices shall be installed as close to the equipment to be protected as practically possible.

E. Device Locations: As a minimum, provide surge protection devices at the following locations:

1. At any connections between ac power and electrical and electronic equipment, including panels, assemblies, and field mounted analog transmitters.

2. At both ends of all analog signal circuits that have any portion of the circuit extending outside of a protecting building.

3. At both ends of all copper-based communications cables which extend outside of a building, including at field instruments and the field side of analog valve position signals.

4. On all external telephone communications lines.

2.02 AC POWER PROTECTION

A. Surge protection device assemblies for connections to AC power supply circuits shall:

1. Be provided with two 3-terminal barrier terminal strips capable of accepting No. 12 AWG solids or stranded copper wire. One terminal strip shall be located on each end of the unit.

2. Enclosure: All required equipment shall be installed inside a stainless steel enclosure equipped with a subpanel and interior swing open dead front door. The Enclosure is located in a non-hazardous but corrosive location, outdoors exposed to weather. Circuits originating from enclosure extend into an NFPA-820 and NEC rated C1 D2 Group D hazardous (classified) area. Separate all wiring for intrinsically safe circuitry in accordance with NEC Article 504.

3. Be constructed as multistage devices consisting of gas tube arrestors, high energy metal oxide varistors, or silicon avalanche suppression diodes. Assemblies shall automatically recover from surge events, and shall have status indication lights.

4. Comply with all requirements of UL 1449, second edition.

5. Be able to withstand a peak surge current of 10,000 amps based on a test surge waveform with an 8-microsecond rise time and a 20-microsecond exponential decay time, as defined in UL 1449.

6. Have the following characteristics:

Transient Voltage Surge Suppressor (TVSS) or surge protective device shall be provided, prewired inside the enclosure. The UL 1449, 2nd Ed., surge protective device (SPD) shall provide 4-mode, line-voltage surge protection for the control panel incoming power supply. The SPD shall have a minimum surge rating of 200kA/phase, with each phase having its own status indicator.

Surge current modes are Line to Neutral, Line to ground, Neutral to Ground, and Line to Line, and each mode shall have a minimum of 100kA/phase protection. The TVSS shall be provided with a line-side, manual disconnecting switch inside the panel to simultaneously disconnect all ungrounded conductors for maintenance. Lead lengths shall be as short as possible.

B. Surge protection device assemblies for connections to AC power supply circuits shall:

1. Have four lead devices and DIN Rail mounting.

2. Have a nonflammable enclosure that meets or exceeds UL 94 V0 flammability requirements.

3. Be constructed as multistage devices consisting of gas tube arrestors and silicon avalanche suppression diodes. Gas tube arrestors and diodes shall be separated by a series impedance of no more than 20 ohms. Assemblies shall automatically recover from surge events.

4. Comply with all requirements of UL 497B.

5. Be able to withstand a peak surge current of 10,000 amps based on a test surge waveform with an 8-microsecond rise time and a 20-microsecond exponential decay time, as defined in UL 1449.

6. Limit line-to-line voltage to 40 volts on 24VDC circuits.

7. Have the following characteristics:

   a. Maximum Continuous Operating Voltage: 28VDC
   b. Ambient Temperature Range: -20 degrees C to +65 degrees C
   c. Response Time (Line-to-Line): 5 ns

8. Both the AC and analog surge protection shall be mounted in a polycarbonate NEMA 4X enclosure base with a clear polycarbonate cover.

9. AC Power/Signal combination surge protection devices systems shall be the EDCO SLAC series as manufactured by Emerson, Phoenix Contact or equal.

2.03 ANALOG SIGNAL CIRCUIT PROTECTION

A. Surge protection device assemblies for analog signal circuits shall:

1. Have four lead devices and DIN Rail mounting.

2. Have a nonflammable enclosure that meets or exceeds UL 94 V0 flammability requirements.

3. Be constructed as multistage devices consisting of gas tube arrestors and silicon avalanche suppression diodes. Gas tube arrestors and diodes shall be separated by a series impedance of no more than 20 ohms. Assemblies shall automatically recover from surge events.

4. Comply with all requirements of UL 497B.

5. Be able to withstand a peak surge current of 10,000 amps based on a test surge waveform with an 8-microsecond rise time and a 20-microsecond exponential decay time, as defined in UL 1449.

6. Limit line-to-line voltage to 40 volts on 24VDC circuits.

7. Have the following characteristics:

a. Maximum Continuous Operating Voltage: 28VDC
b. Ambient Temperature Range: -20 degrees C to +65 degrees C
c. Time (Line-to-Line): 5 ns

2.04 COMMUNICATION CIRCUIT PROTECTION

A. Surge protection devices for copper-based data communication circuits shall:

1. Be designed for the specific data communication media and protocol to be protected (i.e. telephone, serial, parallel, network, data highway, coax, twinaxial, twisted pair, RF, etc.).

2. Provide protection of equipment to within the equipment's surge withstand levels for applicable standard test wave forms of the following standards:

a. IEC 60-1 / DIN VDE 0432 part 2
b. CCITT K17 / DIN VDE 0845 part 2
c. IEEE C62.31

3. Have a nonflammable enclosure that meets or exceeds UL 94 V0 flammability requirements.

4. Provide automatic recovery.

PART 3 -- EXECUTION

3.01 REQUIREMENTS

A. None.

- END OF SECTION -

SECTION 17701

MAGNETIC FLOW METERS

## PART 1 -- GENERAL

### 1.01 THE REQUIREMENT

A. The Contractor shall furnish, test, install and place in satisfactory operation the magnetic flow meters, with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

### 1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 17000 – Control and Information System Scope and General Requirements

B. Section 17600 – Instruments, General

## PART 2 -- PRODUCTS

### 2.01 MAGNETIC FLOW METER SYSTEMS

A. Magnetic flow meter systems shall include a magnetic flow tube and a microprocessor-based "smart" transmitter that is capable of converting and transmitting a signal from the flow tube. Magnetic flow meters shall utilize the characterized field principle of electromagnetic induction, and shall produce DC signals directly proportional to the liquid flow rate.

B. Each meter shall be furnished with a 316 stainless steel or carbon steel metering tube and carbon steel flanges with a polyurethane, ceramic, neoprene, hard rubber, or Teflon liner as required by the application and/or as specified herein. Liner shall have a minimum thickness of 0.125 inches. The inside diameter of the liner shall be within 0.125 inches of the inside diameter of the adjoining pipe. Liner protectors shall be provided on all flow tubes.

C. The flow tube shall be provided with flush mounted electrodes.

D. Grounding rings shall be provided for both ends of all meters.

E. All materials of construction for metallic wetted parts (electrodes, grounding rings, etc.) shall be minimum 316 stainless steel, but shall be compatible with the process fluid for each meter in accordance with the recommendations of the manufacturer.

F. Flow tube shall be rated for pressures up to 1.1 times the flange rating of adjacent piping. System shall be rated for ambient temperatures of -30 to +65°C. Meter and transmitter housings shall meet NEMA 4X/IP66 requirements as a minimum. When meter and transmitter are located in classified explosion hazard areas, the meter and transmitter housings shall be selected with rating to meet the requirements for use in those areas. Where the flow tube is subject to submergence through installation in a meter vault or similar location, the flow tube assembly shall be rated NEMA 6P/IP68 and electronics shall

be factory sealed against moisture intrusion. The use of field kits for modifying NEMA 4/4X/IP66 flow tubes to submergence duty shall not be acceptable. The associated transmitter shall be located in an area not subject to submergence.

G. The transmitter shall provide pulsed DC coil drive current to the flow tube and shall convert the returning signal to a linear, isolated 4-20 mA DC signal. The transmitter shall utilize "smart" electronics and shall contain automatic, continuous zero correction, signal processing routines for noise rejection, and an integral LCD readout capable of displaying flow rate and totalized flow. The transmitter shall continuously run self-diagnostic routines and report errors via English language messages.

H. The transmitter's preamplifier input impedance shall be a minimum of $10^9$-$10^{11}$ ohms which shall make the system suited for the amplification of low-level input signals and capable of operation with a material build up on the electrodes.

I. The transmitter shall provide an automatic low flow cutoff below a user configurable low flow condition (0-10%). The transmitter's outputs shall also be capable of being forced to zero by an external contact operation.

J. Each flow tube shall be factory calibrated and assigned a calibration constant or factor to be entered into the associated transmitter as part of the meter configuration parameters. Manual calibration of the flow meter shall not be required. Meter configuration parameters shall be stored in non-volatile memory in the transmitter. An output hold feature shall be provided to maintain a constant output during configuration changes.

K. The transmitter shall be capable of communicating digitally with a remote configuration device via a frequency-shift-keyed, high frequency signal superimposed on the 4-20 mA output signal. A password-based security lockout feature shall be provided to prevent unauthorized modification of configuration parameters.

L. Accuracy shall be 0.25% of rate over the flow velocity range of 0.3 to 10.0 m/s (1.0 to 33 ft/sec). Repeatability shall be ± 0.1% of rate; minimum turndown shall be 100:1. Minimum required liquid conductivity shall not be greater than 5 uS/cm. Maximum response time shall be adjustable between 1 and 100 seconds as a minimum. Transmitter ambient temperature operating limits shall be -10 to +50°C. Power supply shall be 115 VAC, 60 Hz.

M. Flow tubes shall be 150-lb flange mounted unless otherwise noted. The cables for interconnecting the meter and transmitter shall be furnished by the manufacturer. Transmitter shall be mounted integrally on flow tube, wall, or 2-inch pipe mounted as shown in the Drawings and/or as specified.

N. Magnetic flow meter systems shall be as manufactured by Rosemount, ABB/Fischer & Porter, Endress + Hauser, Toshiba or equal.

2.02 MAGNETIC FLOW METERS - SCHEDULE

| Tag Number | Service Description | Range | Line Size | Remarks |
|---|---|---|---|---|
| FE/FIT – 1 | Station Discharge Flow | 0 – 3,500 gpm | 12” | |

PART 3 -- EXECUTION

3.01 REQUIREMENTS

A. Ground magnetic flow meter flow tubes and grounding rings in strict accordance with the manufacturer's recommendations.

B. Refer to Section 17600 – Instruments, General, Part 3, for further requirements.

- END OF SECTION -